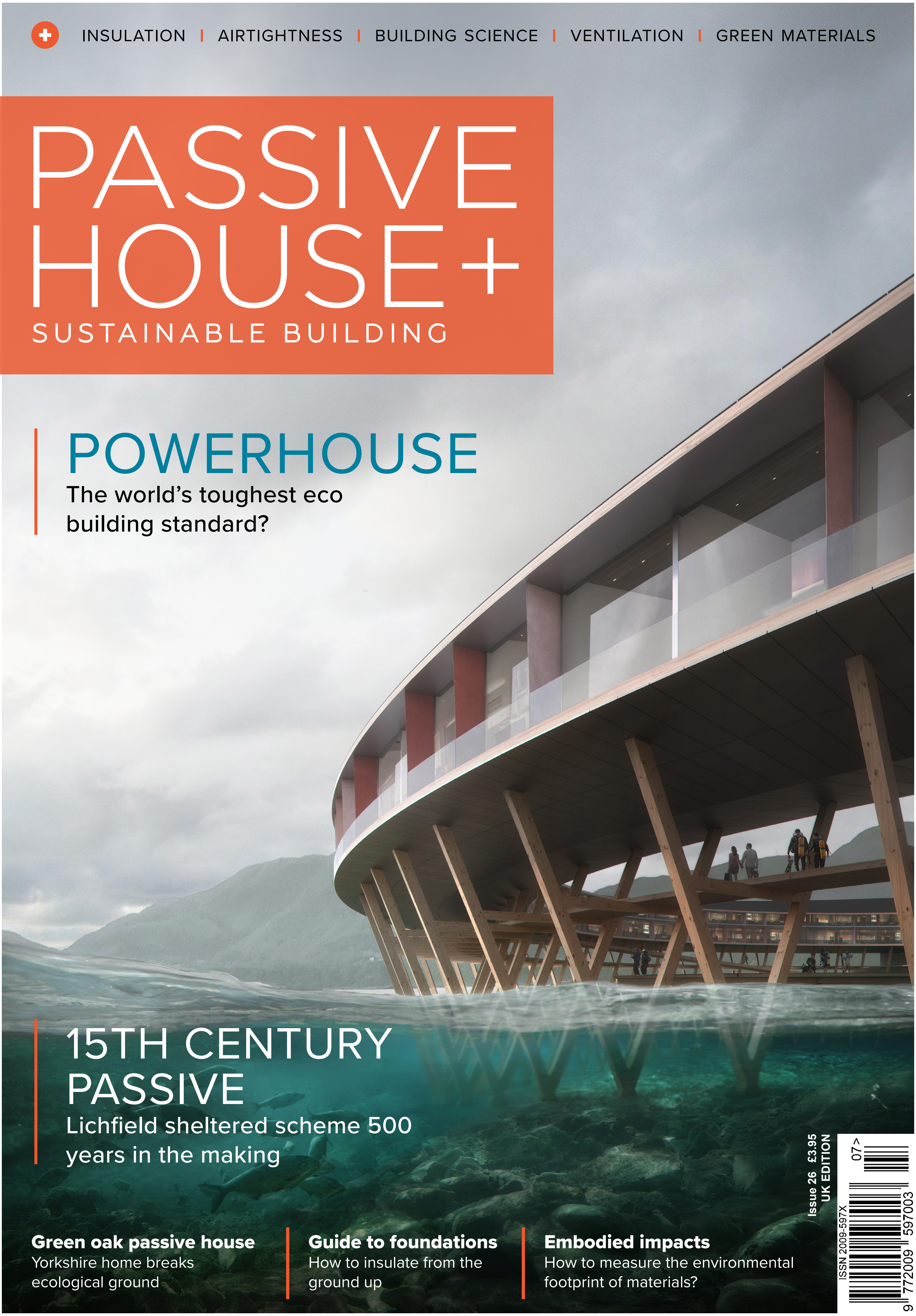
PASSIVE HOUSE+

SUSTAINABLE BUILDING



POWERHOUSE

The world's toughest eco building standard?

15TH CENTURY PASSIVE

Lichfield sheltered scheme 500 years in the making

Issue 26 £3.95
UK EDITION

Green oak passive house
Yorkshire home breaks ecological ground

Guide to foundations
How to insulate from the ground up

Embodied impacts
How to measure the environmental footprint of materials?

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Cover
Powerhouse Svart, a hotel planned in northern Norway
Photo by Snøhetta

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editor's letter

ISSUE 26

Among print media publishers, the disruptive impact of the internet has generally been regarded as negative. Circulations have dropped and advertising income has nosedived, with publishers typically struggling to tap into online income to make up the shortfall. But it doesn't have to be so.

It could be that at Passive House Plus we're in a luckier space, publishing a magazine in a sector – sustainable building – which has slowly emerged from the periphery into the mainstream (aided greatly by a hardcore of extremely loyal advertisers and readers, without whom we wouldn't exist). That process has created a growing demand for reliable, technically literate information – primed by constantly shifting goalposts due to changing building regulations, and industry understanding of the techniques and technologies that will actually prove reliable and cost-effective enough to use. And many of our readers seem to enjoy consuming this information in a well-presented magazine, free of the distractions that on-screen reading brings too easily.

But while we're still as buoyant as ever about print – at least for specialist media like Passive House Plus – we're also excited to announce Marketplace+, a brand new online platform that we've been toiling over for longer than I'd care to admit. Marketplace+ is set for a soft launch on www.passivehouseplus.co.uk on 1 August and will really make our website come to life. If you were to be unkind, you might describe it as a sustainable building directory. But it's so much more than that. The paid listings on Marketplace+ are more akin to websites hosted within our site – websites with detailed information on all the product suppliers, designers, tradespeople, specialist consultants and testers you'd need to build a robust, sustainable building.

We've taken care to stitch Marketplace+ seamlessly into our site, and like the magazine, it'll sit under the Passive House Plus brand. That's because one of the most novel features of Marketplace+ is how it builds on and integrates with the articles we've published over the years and archived online. Take our case studies. As the four exemplary projects featured in this issue show, when we write about buildings we don't just tell the story of the build, describe the challenges that the team overcame, and try to create a palpable sense of what it's like to live in buildings that are always airy, comfortable and cheap to run. We also go into real depth about how they were built – down to the specific products used, and the companies who helped to design and construct the building. We've published literally hundreds of such examples over the years. So what do we do with this resource, that's sitting there online? We've built Marketplace+ to link articles and our gold and platinum listings, so that the articles link to detailed listings of the companies involved, and a list of reference articles appears alongside the company listing pages.

Our core focus at Passive House Plus is to give people robust, practical information on how to build high quality, low energy buildings. We're confident that Marketplace+ will enable us to engage with a larger audience – people who may come to us just because they Google a given supplier who has a listing, but find they've chanced upon a resource that will help them to educate and inform themselves on how to apply those products successfully. We hope it also serves our loyal readers well, and helps to ensure that Passive House Plus is not just stimulating and informative, but a catalyst for the construction and renovation of buildings fit for the 21st century.

Regards,
The editor

About
Passive House Plus is an official partner magazine of The Association for Environment Conscious Building, The International Passive House Assocation and The Passivhaus Trust.

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Filling the retrofit policy void

The imperative to engage in evidence-based deep retrofit grows by the day. With the UK government dragging its heels, Peter Rickaby finds signs of hope in local initiatives, and in burgeoning Irish efforts.

I have often lamented the lack of domestic retrofit policy in England. It is a topic that the UK Government seems incapable of engaging with coherently. Improving the energy efficiency of twenty million homes is at the heart of the challenge of climate change and critical to meeting our national emissions targets. But the 'flagship' Energy Company Obligation (ECO) programme gets ever smaller and ever more narrowly focused on fuel poverty, and on the delivery of single improvement measures. The series of retrofit disasters (in Glasgow, Edinburgh, Preston and at Grenfell Tower, amongst others) has sapped confidence, inhibited investment and seen many closures. The consultation on the next round of ECO proposes 'innovation credits' for multi-measure retrofits – as if we haven't known that whole-house retrofit is best since Retrofit for the Future, almost ten years ago. The single beacon of hope is Each Home Counts, struggling to impose a retrofit Quality Mark on an unenthusiastic industry that grew up delivering single measures badly but reluctantly acknowledges the need for change.

I took heart from a recent discussion of retrofit standards with the Scottish Government. Scotland has a challenging but realistic retrofit programme based on an assessment of the housing stock, an appraisal of the improvements each dwelling type needs by 2050, and a 'fabric first' approach, which despite lack of resource is setting off in the right direction. Similar programmes continue in Wales, where scale retrofit programmes are now the norm, and from where some of the best lessons about how (and how not) to insulate solid walls in exposed areas have emerged.

In Ireland, SEAI's exemplary Deep Retrofit programme is coming to the end of its first year. The programme has taken the 'no insulation without ventilation' maxim seriously and combines good standards of insulation with demand-controlled centralised mechanical extract ventilation (DC cMEV) or MVHR. Since many homes in Ireland have no mains gas, domestic electric heat pump technology is probably as advanced as anywhere in Europe. When I want a domestic heat pump consultant, supplier or installer, or just to learn how to use the technology properly, Ireland is the go-to place.

Where does that leave those in England? All is not lost, because quietly, following nudges from Green Deal Communities and RE:NEW in London, city authorities have been stepping into the policy void with their own initiatives. The GLA's Energy for Londoners programme retains a focus on fuel poverty but is working with RetrofitWorks to adopt a robust approach. A retrofit coordinator will be deployed on every project, homes will be subject to whole-house assessment, and whole-house medium-term retrofit plans will be formulated, even if they cannot be fully implemented immediately. Assessment and upgrading of ventilation, whenever fabric measures may reduce the infiltration rate, is also part of the approach. Similar programmes are emerging in other cities, notably Manchester, Bristol and Oxford, and others will not be far behind.

As localisation continues, the next challenge will be to mobilise the repairs, maintenance and improvement (RMI) industry, which is three times the size of the retrofit industry, to improve energy efficiency in towns, villages and rural areas. The local companies and tradesmen who form the RMI industry are skilled but often reluctant to embrace new techniques. Marshalling their skills to integrate retrofit with RMI work will require new incentives and new approaches to funding, training and quality assurance.

> The retrofit imperative abhors a vacuum: local initiatives are filling the national policy void.

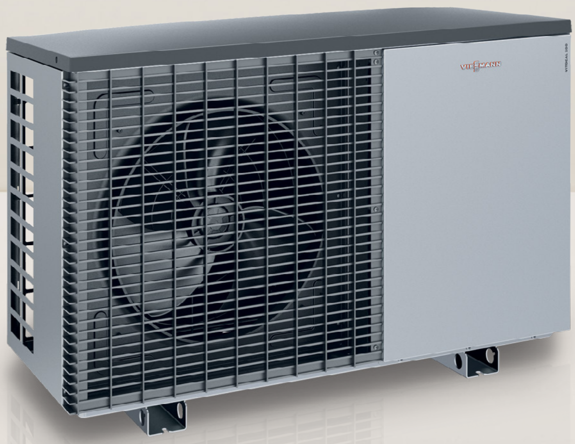
Against this backdrop of local retrofit, involving many small organisations, standards are important. The emerging standard to support the Each Home Counts Quality Mark is BSI's PAS 2035 Specification and Guidance for Domestic Retrofit. PAS 2035 builds on Ireland's excellent NSAI SR 54: 2014 Code of Practice for the energy efficient retrofit of dwellings and goes a few steps further. It will require: whole-house assessments; risk assessment of projects to determine the standards that apply and the required qualifications for project managers and designers; assessment and upgrading of ventilation; designs that take account of the interactions and interfaces between measures; and monitoring and evaluation. For more complex projects PAS 2035 will also require comprehensive improvement option evaluation, moisture risk assessments in accordance with BS 5250 and the preparation of medium-term retrofit plans.

The UK retrofit environment, while not benefitting from a coherent national policy, is not stagnant. The retrofit imperative abhors a vacuum: local initiatives are filling the national policy void. Much is going on in the devolved nations and at city level, and retrofit programmes are being localised. Meanwhile Each Home Counts is putting together the necessary infrastructure of standards and quality assurance. ■

Peter Rickaby is a Trustee of the National Energy Foundation, a member of the Each Home Counts Implementation Board, chairs the BSI Retrofit Standards Task Group and is the training lead for the UK Centre for Moisture in Buildings at UCL. The opinions expressed here are his own.

NEW Vitocal 200-A

Air source heat pump that raises the bar higher



Vitocal 200-A heat pumps utilise the heat in outdoor air for environmentally responsible and cost effective heating. The monobloc unit is available for use either solely for heating or for heating and cooling.

Benefits for installers

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- Quick and straightforward installation of the monobloc indoor unit
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- No minimum clearances required between indoor and outdoor units
- High quality components for long lasting, robust operation
- Easy front access to all components

Benefits for users

- One of the quietest models on the market thanks to Advanced Acoustic Design (AAD)
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- Easy to operate Vitotronic control unit with graphic display
- No refrigeration inspection required thanks to the monobloc format
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WANT TO KNOW MORE?

More information on the Powerhouse standard is available in Norwegian at **www.powerhouse.no**. A detailed PDF description of the standard in English, courtesy of Powerhouse, is available for subscribers and will accompany digital versions of this article.

Photos: Powerhouse Drøbak - Robin Hayes / Snøhetta

POWERHOUSE: THE WORLD'S TOUGHEST ECO-BUILDING STANDARD?

Forget passive house, is Powerhouse the most crazily ambitious energy-related building standard around? The Norwegian benchmark demands that to meet it, a building must produce more renewable energy over its lifetime than is used for the manufacturing of all materials in the building — plus its construction, operation, future renovation and demolition.

In other words, a powerhouse must generate more from renewables over a 60-year period, a typical building's lifespan, than the building's entire life cycle energy consumption.

But before you even start calculating how much renewable energy a powerhouse produces, it must first meet the passive house standard , to ensure it is as energy efficient as possible.

Powerhouse buildings must meet other criteria too: they must be sold or rented at normal market rates, provide a healthy indoor climate, and produce all their renewable energy on-site (or close by, if wave or tidal energy is being used).

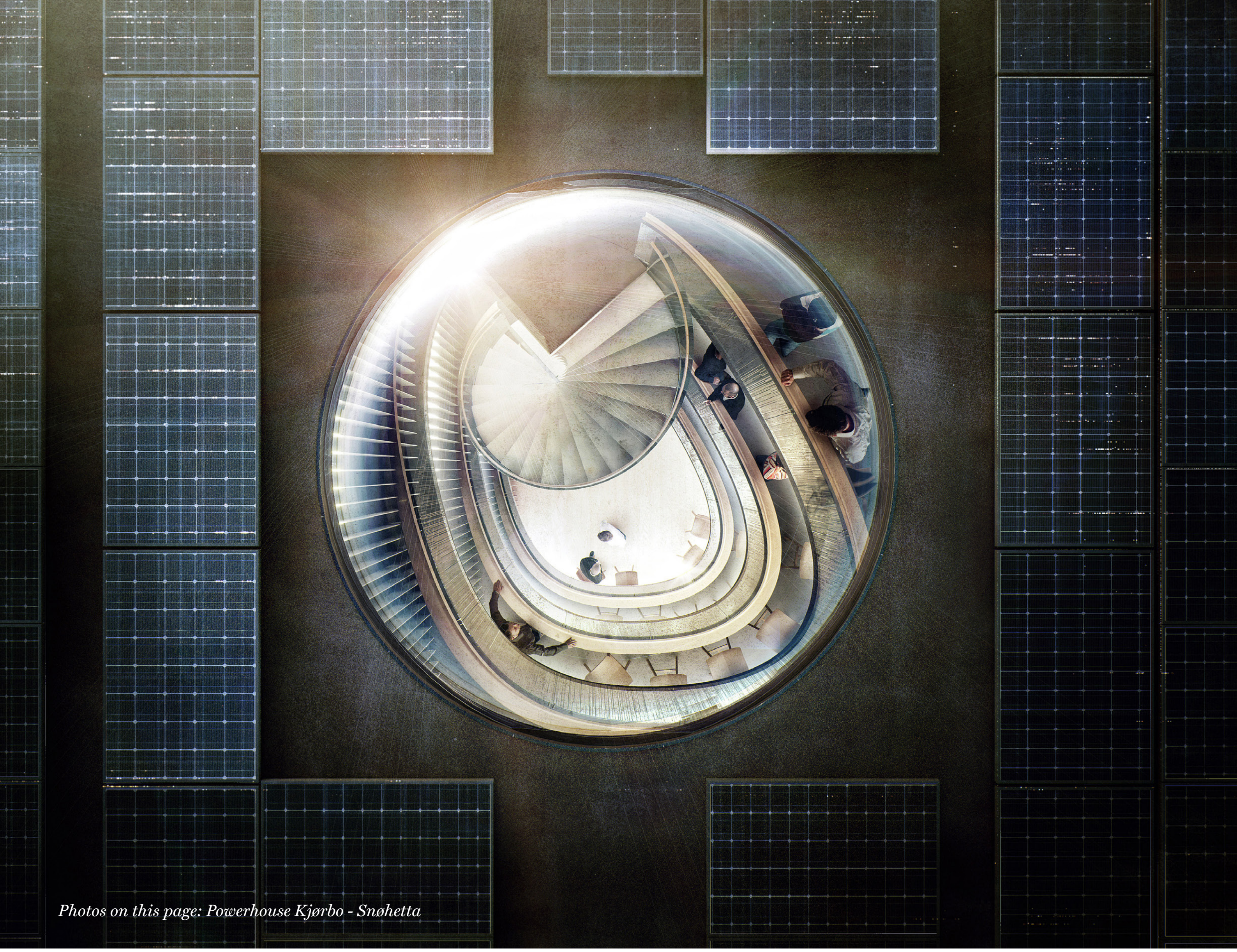
The Powerhouse project is a collaboration between leading international architecture practice Snøhetta, Swedish contractor Skanska, the environmental NGO Zero, and various others.

The first building finished to the standard was Powerhouse Kjørbo, the deep retrofit of two 1980s office buildings outside Oslo, completed in 2014.

The buildings' glazed facade was replaced with new triple glazing and insulated panels clad with burnt timber, while the original windows were re-used for interior partitions.

More than 90% of construction waste on the project was recycled or reused, and the finished buildings now boast a massive 1,500 square metre rooftop solar photovoltaic array that produces twice the buildings' demand.

The second powerhouse building, a Montessori secondary ▶



Photos on this page: Powerhouse Kjørbo - Snøhetta

Photo: Powerhouse Kjørbo - Snøhetta

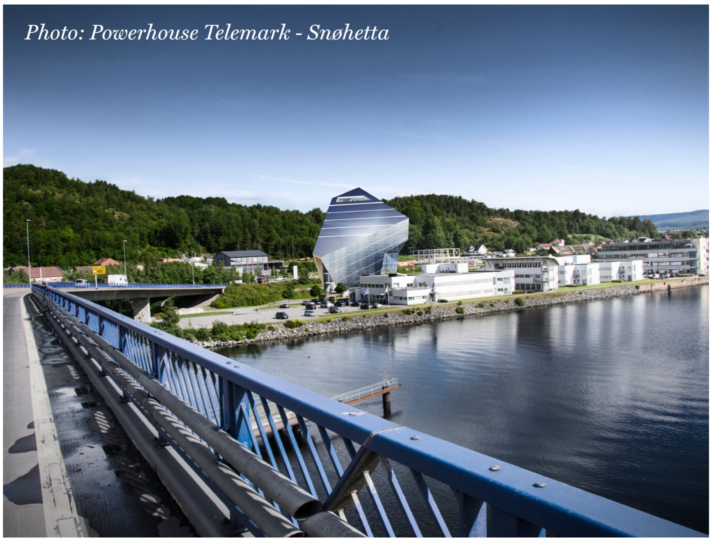


Photo: Powerhouse Telemark - Snøhetta

school in Drøbak, was finished earlier this year.

Surrounded by forests and sitting high above the Oslofjord, the timber frame school is expected to produce an estimated 30,500 kWh of solar power annually. It features an angular 'solar plate' that is clad with south-facing PV panels at a slope of 33 degrees.

The disc also forms a ventilation 'stack' that expels rising stale air and gathers incoming fresh air, to supplement the building's heat recovery ventilation system.

"We think the building will facilitate increased understanding, wonder and respect for nature. We are looking forward to moving into the greenest school in Norway," says Mervi Flugsrud of Drøbak Montessori.

The next project built to the standard will be Powerhouse Telemark, an office building in the Norwegian town of Porsgrunn, set to be finished early next year.

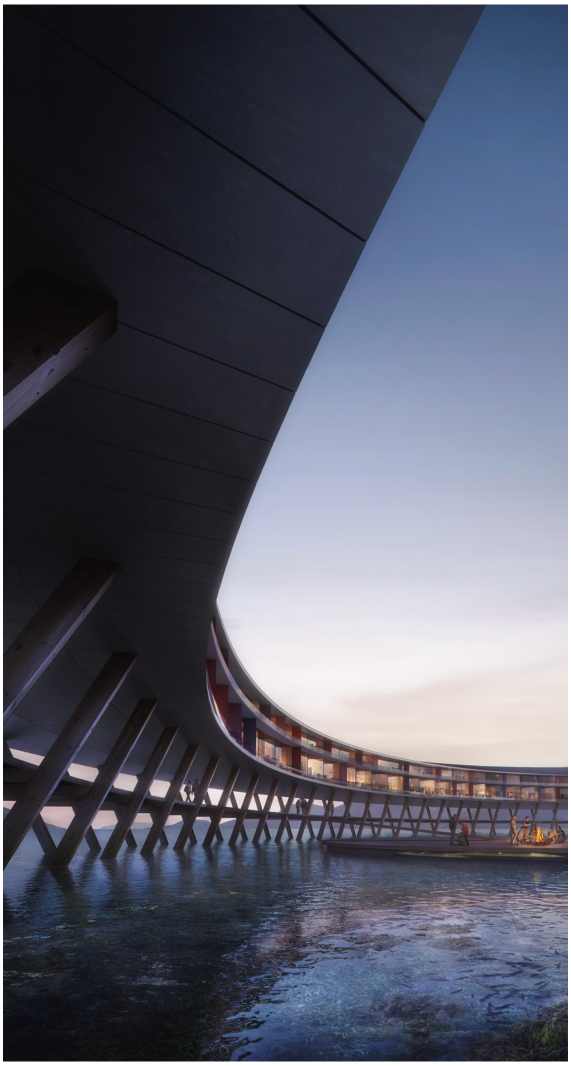
But the perhaps the real jewel in the Powerhouse crown will be Svart, a stunning hotel planned for the foot of the Svartisen glacier in Norway's arctic.

The circular building will be constructed primarily of timber and rest on "weather-resistant wooden poles" that stretch in the clear waters of Holandsfjorden.

To prepare for the project and maximise the efficiency of its solar PV systems, Snøhetta conducted an extensive project to map how solar radiation behaves in the fjord, which is surrounded by high mountains but also experiences very long summer nights and correspondingly short winter days. The hotel is set to be complete in 2021.

(this page, top to bottom) telephone pods in the open plan offices at Powerhouse Kjørbo; an artist's impression of Powerhouse Telemark, an office building set to be finished in 2019; and below, a rendering of the spectacular Powerhouse Svart, a hotel currently under construction in the north of Norway; (opposite) an artist's impression of the solar PV system on the roof of Powerhouse Kjørbo, and below, the upgraded building, clad with insulated panels that are finished with burnt timber; (p10 & 11) Powerhouse Drøbak, a new Montessori school built to the ambitious standard that opened earlier this year; (p14) more artist's renderings of Powerhouse Svart, which will sit on timber poles in the waters of Holandsfjorden.

Photo: Powerhouse Svart - Snøhetta / Plompmozes

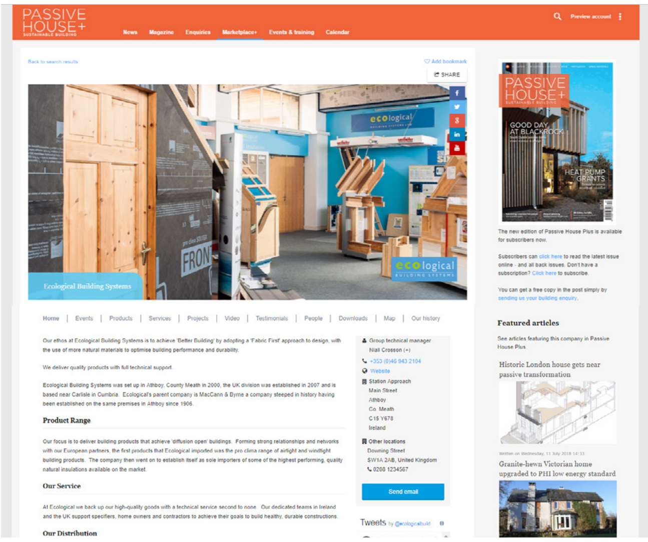


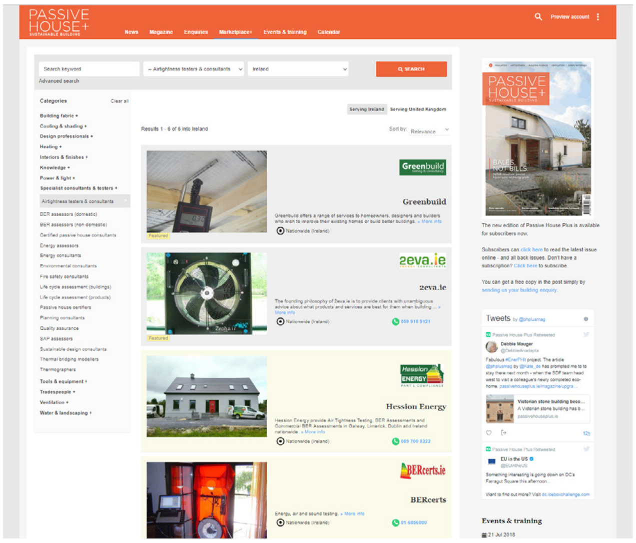
Photos on this page: Powerhouse Svart - Snøhetta / Plompmozes

NEWS

Passive House Plus to launch sustainable building web directory

Marketplace+ to provide a new content-rich 'online ecosystem' for the sector





(above left) A mock-up listing page - including a number of tabulated pages and links in the right hand column to featured articles related to this listing; (above right) a mock-up of search results with platinum, gold, silver and free listings appearing in sequence.

Passive House Plus is excited to premier its unique new web platform for the sustainable building sector, Marketplace+, on 1 August.

Marketplace+ is designed to provide a shop window for the leading companies in sustainable building to promote their businesses and connect with potential clients, specifiers, tradespeople and partners.

"In simple terms, Marketplace+ is an online directory for companies in the sustainable building sector," said Passive House Plus publisher and editor Jeff Colley.

"But in reality it's so much more. It's an online ecosystem for businesses in this area, and it will be stitched into the very fabric of the Passive House Plus website."

Companies featured on Marketplace+ can choose a range of advertising options, from simple free listings to feature-packed platinum listings that effectively serve as self-contained websites, hosted within passivehouseplus.co.uk.

"What's really exciting about Marketplace+ is how it's seamlessly integrated into our website, offering businesses the chance to market to a targeted, highly motivated, and captive audience," explained Jeff Colley.

"For example, the featured companies module for Marketplace+ means that a graphic link to your listing will appear alongside any article on our website that mentions your company name.

"Equally, the featured articles module means that any article featuring your company will appear alongside your company's page on Marketplace+. This keeps your listing fresh with new content as you appear in new articles."

Depending on which level of listing a business chooses, it can include a wide variety of features, including a tiered products and services' section — with categories and sub-sections for individual products/services featuring photos, text descriptions and buttons to request information or a quote.

There's also a home tab with text, a contact form, integrated Twitter and Facebook feeds, and links to up to seven social media services; a projects tab which includes captioned photo galleries and descriptions of projects; a videos tab, a downloads section for company brochures and other literature, and an events tab that links in with our overall searchable calendar for CPD events, conferences and more.

Marketplace+ also includes a multi-factor search system that allows users to search for, say, external insulation suppliers in Ireland that have NSAI Agrément certification, architects who are certified passive house designers, etc.

The platform will undergo a 'soft launch' on 1 August, with additional new features planned in the coming months.

"Marketplace+ represents a major step for Passive House Plus in our ambition to inform, educate and act as a catalyst and conduit to help people build better buildings," said Jeff Colley.

Visit **www.passivehouseplus.co.uk** from 1 August onwards to see the new service, or contact **jeff@passivehouseplus.co.uk** to enquire about getting your business listed. ■

Study: extreme overheating not reflected in building simulations

Words by Jeff Colley

Dangerous overheating in buildings may not be showing up in desktop studies, new research suggests.

Monitored operative temperatures of up to 47.5C recorded in a highly glazed apartment building in London were not reflected in software modelling of the same building, with temperature peaks in simulated scenarios between 18C and 30C cooler, depending on which weather files were used.

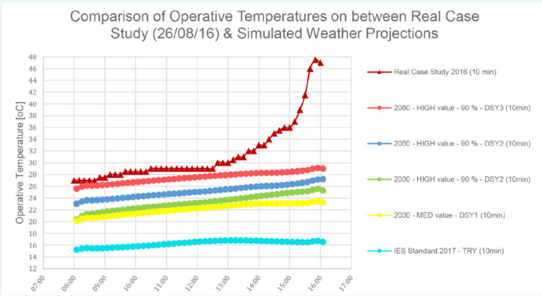
In 2016, London Southbank University (LSBU) researchers monitored the apartment building in Camden, which was reported to be overheating. Converted from a factory, overheating in the highly-glazed southwest-facing units became apparent during the renovation – with workers reporting that the temperatures were affecting materials and methods on-site.

"When the building was left unoccupied for 5-6 weeks, the building manager found that the waste pipe water had evaporated leaving no protection against odour ingress from the sewage system," noted the study. The British Blind and Shutter Association (BBSA) was approached to advise on the impact shading could have on comfort levels within the building – research which was then led by Zoe De Grussa and colleagues from LSBU.

The researchers began monitoring two identical apartments in the untenanted building – on the first floor & directly above on the second floor of the four-storey building – choosing two bedrooms in each case. One room was left unshaded, while blinds were fitted in the others – internal and external 80mm aluminium venetian blinds, internal and external screen fabric roller blinds, and an internal reflective screen fabric roller blind. Double glazed windows with a stated U-value of 1.1 had been installed as part of the retrofit. "No g-value was given by the building developer but the glazing specifier advised that the glazing alone would be adequate to control the solar gains on all façades," the report notes. Windows and internal doors in the otherwise unventilated apartments were left open from 4:30pm till 8am each day to allow passive night cooling, and data was logged and analysed from 16 days between August and October 2016 – including indoor temperatures and external air temperatures.

On day three, when the peak external air temperature was 27.9C, the peak operative temperature in the unshaded room was 47.5C – while a room with external aluminium venetian blinds at 45° peaked at 29C, and rooms fitted with internal venetians and screen fabric recorded peaks of 34.5C and 32C respectively. On days nine to eleven, when external temperatures peaked at between 20.1 and 21.4C, operative temperatures in the unshaded control room peaked at between 42 and 45C – indicating extreme temperatures may be reached in comparatively mild summer conditions.

A follow-up desktop study by an LSBU team led by Luigi Venturi was conducted on the same building, using the IESVE software, with the results presented at a CIBSE Technical Symposium in London on 12-13 April. The model simulated conditions in the unshaded control room, with internal venetian blinds assumed in the other three rooms, as the software doesn't allow for moveable external shading. A g-value of 0.4 was assumed for the glass.



A 2017 Test Reference Year (TRY) weather file from IES was put into the model alongside UK Climate Projections Design Summer Year (DSY) weather files for 2030, 2050 and 2080. The results for operative temperature projections in the unshaded room are striking: the IES simulated peaks are up to 30.77C lower than the monitored peak where the 2080s weather projections are 18.39C lower.

The author of the study acknowledges that when reviewing overheating in buildings it is unreliable to use TRY weather data and a DSY should be used as it includes predictions of future overheating weather events as recommended by CIBSE TM59.

The study also found that when 2080 projected external air temperature peaked at over 41C, the unshaded room was predicted to peak at under 38C – nearly 10C cooler than the logged 2016 data.

The BBSA commissioned a report by an energy modeller at the National Energy Foundation (NEF), including quality assurance on the LBSU model and a sensitivity analysis on shading configurations from software-maker IES, which found that adjusting the input for shading to minimum and maximum values changed the end result by less than 2C.

Passive House Plus contacted IES, who reviewed the LSBU model and associated NEF report. An IES spokesperson said: "The report alerted the modeller to a series of issues present in the LSBU model and it is unclear whether these have been fully and properly addressed before collating the results that are used in the LSBU study. The model received by IES does not appear to have included these recommendations.

"When publically [sic.] communicating the findings from studies like these, it is crucial the modelling has been independently reviewed by a competent authority and any recommendations addressed otherwise the findings can be misleading. In our checks we could find no evidence that such a review has been carried out and on the basis of our own model review IES do not believe that this study should be used as a reliable benchmark for simulation model accuracy, as a critique of the simulation model's capability to predict future performance or to calibrate model results against existing building performance."

Passive House Plus issued a number of follow-up questions to IES including: whether IES would share its model review; what issues IES had found with the LSBU model and what their respective and cumulative effects were; whether IES has modelled the building itself and if so, what results it had found; whether there are any points raised in the NEF report that the LSBU didn't act upon, and which may have substantially impacted the results; whether a difference of less than 2C was a fair reflection of the difference between the presence or absence of shading; and whether IES regards NEF as a competent authority to conduct a review of these studies, and the associated modelling. IES declined to comment.

Ireland's Department of Housing recently went to consultation on proposals to bring new homes up to nearly zero energy building (nZEB) standard, as required by the EU's recast energy performance of buildings directive. The IESVE software was used by the engineering firm AECOM to assess overheating risk in five example homes, in accordance with CIBSE's TM59 methodology. AECOM noted "marginal exceedances" in four of the nineteen rooms modelled, and proposed mitigation strategies of occupants controlling curtains or blinds when solar radiation is high.

BBSA technical group chair David Bush warned that with EU countries amending building standards to meet nZEB levels, many of the limitations of calculating shading and the assumptions made will be replicated. "We can make the case as in France and Norway that a minimum g-value of 0.15 should be achieved, but if the algorithms of the weather patterns in the model say it will not overheat the problem remains." ■

Performance gap much smaller for passive homes, research finds

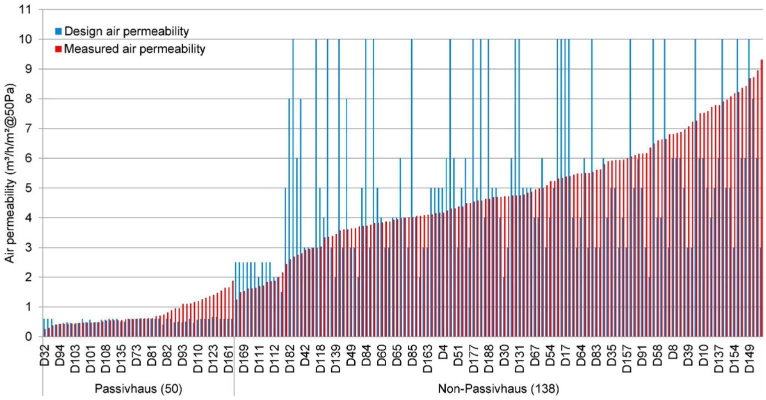
Dwellings built to passive standard consistently perform much closer to design targets, authors conclude. *Words by Kate de Selincourt*

A detailed study of test results from almost 200 low energy homes in the UK suggests that while gaps between designed and real-world energy performance are ubiquitous, these gaps are much smaller in dwellings built to the passive house standard.

Professor Rajat Gupta and Dr Alkis Kotopouleases at Oxford Brookes University, analysed data from the UK's National Building Performance Evaluation programme (begun in 2010 by the then Technology Strategy Board). The 188 homes, comprising 50 passive and 138 non-passive dwellings, were built with a range of construction systems and to various performance targets.

The team analysed the results of air leakage tests, in-situ U-value measurements of walls and roofs, and whole house heat loss.

The biggest set of data was for air permeability. The non-passive homes had a range of air permeability targets, from 1.5 m³/h/m² (at 50 Pascals of pressure, normal test conditions) right up 10 m³/h/m² (the legal maximum).



But the actual results did not have much relationship to the targets, with nearly half of the homes being leakier than the targets, which were often unambitious in the first place. The average air permeability 'overshoot' was almost 2 m³/h/m².

Most of the homes were fitted with mechanical ventilation with heat recovery (MVHR) systems, which would not have been performing efficiently in the 81% of non-passive homes with leakiness worse than 3.0 m³/h/m², the recommended air permeability limit for installing MVHR, the authors point out.

A small number of homes used mechanical extract or 'natural' ventilation. Their permeability targets averaged at 8.5 m³/h/m², but on average these homes actually had better infiltration rates than designed: for in the 'naturally ventilated' homes it was 40% better on average (5 m³/h/m²).

While this could offer energy and comfort advantages, if the ventilation strategy was dependent on air infiltration through the building structure, there could have been implications for indoor air quality. Air quality measurements were not within the scope of this meta-study, though they will be the subject of future research by the same team.

Overall there was barely any relationship between design and delivered air permeability for non-passive dwellings, which suggests that "design air permeability" means nothing in practice, unless the result is tested and enforced, as it is on certified passive house builds.

Meanwhile, just over half the passive dwellings also showed airtightness performance gaps, with worse fabric permeability than target, but in these instances the average gap was only 0.5 m³/h/m², 75% less of a gap than in the non-passive homes. The widest gap was 1.3 m³/h/m² among passive dwellings, and 6.3 m³/h/m² among non-passive dwellings.

U-values & heat loss

In-situ U-values were measured in 20 of the dwellings and these too showed regular discrepancies between targets and measured results, under-performing in three quarters of those measured. The passive house walls measured on average 0.03 W/m²K higher than target, with non-passive dwellings averaging 0.07 W/m²K higher. In ten cases, the wall U-value was worse than that allowed in the building regulations.

Roof U-values also missed their targets, with passive house roofs measuring 44% worse than target on average, and non-passive dwellings 71% worse.

For 29 of the dwellings the whole house heat loss had also been measured, via co-heating tests. Most of the passive dwellings underperformed slightly – these generally showed an 'overspend' of about 4.5 W/K (an overshoot of around 10%). Whole house heat loss in the non-passive dwellings was much more variable, with some even doing better than designed.

However of those non-passive dwellings which underperformed, the gap was much bigger than with the passive dwellings – ten times as big in fact, at an average of 42 W/K, a 30-50% overshoot for many.

As the authors wrote: "the magnitude of underperformance was much less in PH dwellings ... a comparison between the non PH and PH developments [using thermal imaging] revealed a significantly lower frequency of defects amongst the latter, highlighting the importance of attention to detail that is integral in a PH approach."

"Despite the small sample of PH dwellings with a complete set of fabric performance data, it is evident that PH dwellings perform well across all the three in-situ tests, indicating the robustness of the PH standard."

The study also identified a difference between masonry and timber construction. "The fabric performance gap was consistently larger for dwellings with masonry construction. Compared to their timber counterpart, masonry builds were found to be leakier and have higher external wall thermal transmittance and whole house heat loss," the authors wrote.

Although numbers were small, masonry builds had a 20 W/K higher heat loss coefficient on average than the timber-framed dwellings, which averaged very little performance gap.

But the results for passive dwellings showed much smaller deviations from design targets for both masonry and timber construction, "indicating that the quality of detailing and workmanship is more important than the type of construction," the authors wrote. ■

(above) Designed and measured air permeability by ventilation strategy for 50 passive and 138 non-passive dwellings.

Better housing means fewer A&E admissions, study finds

Dampness reduction via better ventilation seen to be key

Quality housing upgrades can help to considerably reduce emergency room admissions, new research from Swansea University has revealed.

The research, led by Prof Sarah Rodgers at the university's medical school, looked at residents living in 9,256 council properties in Carmarthenshire, South Wales. Of these, 8,558 homes had undergone at least one improvement to the Welsh quality housing standard.

These included new heating and electrical systems (including the fitting of extractor fans to kitchen and bathrooms), added wall and loft insulation, new kitchens and bathrooms, new windows and doors, and the installation of safer garden paths.

The team linked monthly hospital admission data, from an anonymised databank, to information provided by the council on the month each home received an improvement. Using this data, the team was able to compare the number of hospital admissions for tenants living in houses that had received upgrades with those who had not.

Their results revealed substantial decreases in the number of hospital admissions for those in the improved homes. This included a decrease of up to 39% in emergency admissions for cardiovascular and respiratory illnesses, as well as for fall and burn injuries, for those in the over 60s age group.

New electrical systems (including extractor fans), new windows and doors, added wall insulation and the installation of safer garden paths were the interventions associated with the biggest reductions in hospital admissions for this age group.

For tenants of all ages, there was a 19% to 34% reduction in hospital admissions for those with new electrical systems, new windows and doors, and improved garden paths, and a 1% to 8% reduction for those with improved heating systems and bathrooms.

"We found that improvements to electrical systems – including fitting extractor fans in kitchens and bathrooms – contributed to the largest reduction (57%) in respiratory related admissions," lead author Prof Sarah Rodgers wrote on research news website **theconversation.com**.

"This leads us to believe the removal of damp from homes using extractor fans was probably an important mechanism behind many of the reduced admissions. And that damp removal improvements are important as part of a whole home intervention."

Prescribed asthma medications and GP visits also dropped in the improved homes for residents of all ages. The team concluded that good housing upgrades could potentially help to reduce strain on the NHS.

Commenting on the findings, Cllr Linda Evans, Carmarthenshire County Council's executive board member for housing, said: "We have already used the heath evaluation results and study team recommendations to update our development plans. We encourage the adoption of the recommendations by local authorities around the UK and further afield. Making small changes in housing policy improves health, which also carries social, economic and environmental benefits for all."

The full paper is available at **tinyurl.com/waleshousingstudy**. ■

The utopian Usonian

Dr Marc Ó Riain looks at the influence of 20th century architectural giant Frank Lloyd Wright on low energy building design.

Over a century ago Frank Lloyd Wright designed the Robie House, the best-known example of the Prairie style house. The three-storey brick house had a horizontal massing, orientated on an east-west axis. The building was designed to be naturally ventilated with stack chimney ventilation, underfloor heating and a large open fireplace. Wright maximised glazing on the southern elevation and limited it on the northern elevation. Cantilevered roof overhangs were calculated to minimise overheating in summer. Although research has shown that the house overheated above 25C "for more than 800 occupied hours per year and higher than 32C for more than 600 occupied hours per year", the house had a far better thermal comfort than many of its contemporaries (Estoque, J. 1987). The 9,000 square foot house cost $55,000 in 1909 or $1.4m (€1.22m, £1.08m) in 2018.

Following the Wall Street crash of 1929, Wright had turned his attention to designing affordable housing for the middle class built on a one-acre plot in a conceptual self-sustaining community called Broadacre City. The garden city concept was the antithesis of high density, high rise, urban planning. It envisioned suburban living focused inward on gardens sustaining domestic food crops. With plenty of skilled labourers but a low availability of credit, Wright sought to rationalise his Prairie House style to be built for $5,000 ($85k in today's money, including the architects fee) for a 1,500 square foot single family home (Sergeant, J. 1984).

Wright's first Usonian House was built in Madison, in 1937, with an L-shaped plan placing the kitchen at the axial point of the plan, centralising all the services at one point. Compact bedrooms with ample storage were located in the short end of the L-shaped plan. A formal dining room was dispensed with in favour of an open plan kitchen/dining/living space, with an outward focus toward the garden placing the parents in a controlling view of the space and garden. The removal of walls took away the formality of the spaces creating a template for modern living that we all still aspire to today. Wright also abandoned the typical basement, favouring a raft foundation with underfloor heating. Long overhangs shade expansive glazing oriented toward the south garden. North elevations were mostly solid with a clerestory window, and Wright's new invention; a car port (minimising the need for expensive enclosing walls).

Lowell Walter Residence, a well-preserved Usonian House in Iowa, built in 1948. Photo by Wikipedia user Orange Suede Sofa - Creative Commons Attribution-ShareAlike 3.0 License

Wright maintained aspects of the Robie House in the linear horizontal massing, stepped internal ceilings, gravity (underfloor) heating, minimal glazing to the north and east, and natural ventilation. The design varies from the in-line plan to an L-shaped plan, pin wheeling about the chimney, with central services, clustered for cost reasons, and a small recessed dining area. The 60 Usonian Houses had a common modular planning and materiality but varied formal language.

One of these formal variations was Wright's second house for the Jacobs family designed in 1943 and built in 1948, which would become known as the Solar Hemicycle. The client did not accept a linear Usonian type solution, challenging Wright for a more innovative solution for the sloping site that faced into the valley. Retaining the modular grid, Wright designed a 180 degree building centred at a point in the sunken garden, oriented along the sun path. The semi-circular two-storey building was essentially one open plan ground floor space with five bedrooms located on a first floor gallery, and a circular tower structure housing plant, stairs and bathroom on the first floor. The home was set out on 6^{0} radius increments cast into concrete floor delineating the building's modulation. The north-facing rear wall was protected by an earth berm up to first floor clerestory windows (allowing for cross ventilation), with two-storey interior stone walls acting as a thermal mass. The house was designed to minimise heat loss from the cold northerly winds, storing heat from the winter sun whilst shading the house's 48' long (14.5m), 14' high (4.2m) south-facing glass wall. The Solar Hemicycle is a seminal precedent in the development of net zero energy buildings, including the principles or orientation, shading, limiting heat loss, using thermal mass, and maximising natural light.

Frank Lloyd Wright's Usonian Houses influenced a generation of architects, pointing the next toward the potentials of passive and zero energy buildings. As wartime created high oil prices the demand for solar houses rose. In the next edition we will look at how another Wright developed solar housing in the US. ■

> "The Solar Hemicycle is a seminal precedent for net zero energy buildings – in orientation, shading, thermal mass, maximising natural light & limiting heat loss."

Dr Marc Ó Riain is the president emeritus of the Institute of Designers in Ireland, a founding editor of Iterations design research journal and practice review, a former director of Irish Design 2015, a board member of the new Design Enterprise Skillsnet and has completed a PhD in low energy building retrofit, realising Ireland's first commercial NZEB retrofit in 2013.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> The solution was to create an internal frame of green oak — with the oak columns standing within the rooms of the house.

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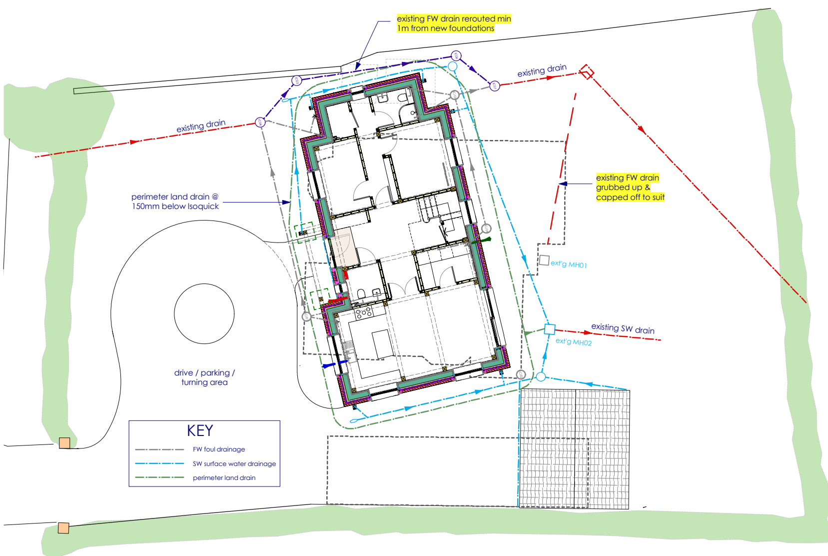
THE UK'S FIRST

GREEN OAK PASSIVE HOUSE

Choosing newly-harvested green oak — which shrinks and moves as it dries — for the millimetre-precise demands of passive house construction was a bold move by Phil Garnett and his wife Yvonne, but one that ultimately gave them one of the most unique and ground-breaking passive homes in the UK.

Words by David W Smith



£305

Gas bill per year (heating, hot water & cooking)

Building: 188 square metre detached green oak house

Location: Hunmanby, Yorkshire

Completed: March 2017

Standard: Passive house certified

When they decided to build a new home in the village of Hunmanby, near the Yorkshire coastline, Dr Phil Garnett and his wife Yvonne intended to create a simple eco-home out of green oak. But somewhere along the way, their plans became much more radical and they ended up constructing the UK's first certified green oak passive house. In doing so, they not only disproved the notion that it could not be done technically, but they also set a powerful precedent for future builds.

"It's been a dream of mine to build a green oak house since I went to a Grand Designs show 20 odd years ago," Phil Garnett says. "But when I approached Andrew Yeats, of Eco Arc architects, in 2014, he suggested going a step further and designing a passive house. It was far more challenging technically, requiring fantastic accuracy in the build and huge amounts of insulation. But we went for it and we love it. I've become an absolute zealot to the cause of passive houses."

From the lounge upstairs at Hilltop House, there are uninterrupted views of 16 miles of coastline, from the high chalk cliffs at Flamborough Head over to Scarborough Castle. "There's nothing between us and the sea except fields. I can sit for hours as the amazing view changes hourly, so I never get bored.

"But it's not just the view we love. During the 'Beast from the East' cold spell, we were basking in 21 degrees without turning the heating on. The airtightness also makes the house so peaceful, and there's no dust whatsoever because the mechanical heat recovery system supplies filtered fresh air," Garnett says.

Cumbria-based architect Andrew Yeats of Eco Arc believes Hilltop House will inspire many others to build passive houses using green oak. "In the past, it was thought that green oak and passive houses could not be bedfellows. But Hilltop House shows you can have your cake and eat it. You can enjoy the beauty of exposed oak frames and also get the thermal qualities required to reach passive house standard," he says.

Yeats believes the British, in particular, will relish the opportunity to bridge the gap between a traditional arts-and-crafts style timber frame aesthetic and the passive house standard. "Offsite pre-fabricated passive houses can be quite clinical and a

Green oak is oak that was felled within the last 18 months. Because it is still drying, it has a high moisture content. But according to Oakwrights the Green Oak is easier to work with than the dried oak, as well as being less expensive.

It's been a dream of mine to build a green oak house since I went to a Grand Designs show 20 years ago.

bit Germanic. There can be acres of plasterboard and it's all fairly stripped back, which suits a modern aesthetic, but a lot of British people like a more traditional house," he says.

From the outset, Yeats was aware of how ground-breaking his design would be. He had to take a metaphorical deep breath, he says, knowing how green oak twists and moves — causing a potential conflict with the need for airtightness in a passive house.

Most homes with green oak frames place the oak columns within the insulation layer. But that wouldn't work for a passive house, because it would displace insulation and create a big thermal bridge.

The solution was to create an internal frame of green oak — with the oak columns standing within the rooms of the house — and then have the cellulose-insulated timber wall panels wrap around the outside of the oak frame, with a gap for movement tolerances between the two. The frame now takes the main structural load of the roof and upper floor; the timber-panel walls sit on the insulated foundation and are self-supporting.

Yeats had to be careful to maintain the airtightness layers in the insulated panels behind the oak frame. Inaccessible joints would be hard to tape up, he says. As a result, the builders fabricated every section so that all the joints between the insulated shell components were visible, and not colliding with the green oak frame. "Instead of having one flat panel meeting another flat panel in a corner, we made an L-shaped panel which was then all pre-taped prior to insulation. So, when we had a butt joint, it was off-centre to a column," he says. This made access for taping easier. "Having expected it all to be difficult, once we established the principle and knew the ground rules, it was straightforward."

The Hereford company Oakwrights was responsible for the construction of the house. Although they build regularly with green oak, they had never worked on a passive house before. "I asked them to switch priorities," says Yeats. "I said 'the oak frame is what it is, and it does what it does. I'm much more interested in the continuity of insulation and protecting the airtightness'. They learned fast and followed our

Photography: Oakwrights / Joseph Holder

instructions to the letter."

Work began on the house in March 2016 and was completed a year later. Yeats visited the site regularly to make sure the butt joints in the insulated panels were thermal bridge free. "I inspected and photographed each one to make sure we had continuity of insulation throughout," he says. "The measurements all prove without doubt that green oak houses can be delivered to a very high passive house quality assurance standard."

Aside from the oak frame and timber-panel walls, the house features a typical checklist of passive house features: south-facing orientation for solar gain, triple-glazed Internorm windows, an insulated foundation system from Isoquick, and a Paul mechanical ventilation heat recovery (MVHR) unit.

Phil Garnett says that even during the 'Beast from the East' earlier this year, the house maintained an indoor temperature of 21C without the gas boiler kicking in. But his wife Yvonne likes to keep it at 23C in the evenings generally, and the couple spent £305 on gas for space heating, hot water and cooking in their first 12 months.

"Now we are living in a home that is maintained at a constant optimal temperature with a continual supply of filtered fresh air from the MVHR," Phil Garnett says. "Combine with this the subtle smell of wood, the visual appeal of the exposed oak frame, and the peace and quiet created by the exceptional soundproofing of the passive house construction, and you have an environment that is perfect for all the senses, generating a fantastic feeling of wellbeing."

CONSTRUCTION IN PROGRESS

1 The ground floor features a 300mm thick Isoquick insulated foundation system, plus 250mm wide insulated upstand to edge of concrete slab; **2** the internal frame of green oak which takes the main structural load of the roof and upper floor; **3** a crane lifting into place the cellulose-insulated timber wall panels, which wrap around the outside of the oak frame; **4** more panels being lifted into place with metal web joists for services visible In the intermediate floor; **5** the oak frame roof structure which is internally exposed; **6** a pre made window ope in insulated panels, with Pro Clima Solitex wind-tight membrane to the outside of the build-up; **7** airtightness taping around the installed Internorm timber-aluminium windows; **8** the oak columns stand within the rooms of the house, with the timber wall panels wrapping around the outside, and a gap for between the two — the gap ensured builders could access the walls internally for airtightness taping, and that any movement of the oak frame over time would not impact on airtightness; **9** MVHR ducting over oak frame.

SELECTED PROJECT DETAILS

Clients: Phil & Yvonne Garnett
Architect & passive house designer: Eco Arc
M&E engineer: Alan Clarke
Civil & structural engineer: Richard Renier Associates
PHPP & thermal bridging analysis: Alan Clarke / Eco Arc
Main contractor: David Warnett
Airtightness tester: Paul Jennings
Timber frame system: Oakwrights
Cellulose insulation: Thermofloc
Wood fibre insulation & airtightness products: Ecological Building Systems
Insulation foundation system: Isoquick
Windows & doors: Ecohaus Internorm
Roof window: Fakro
Heating system: Worcester Bosch
Radiators: Quinn
MVHR: Green Building Store
Clay roof tiles: William Blythe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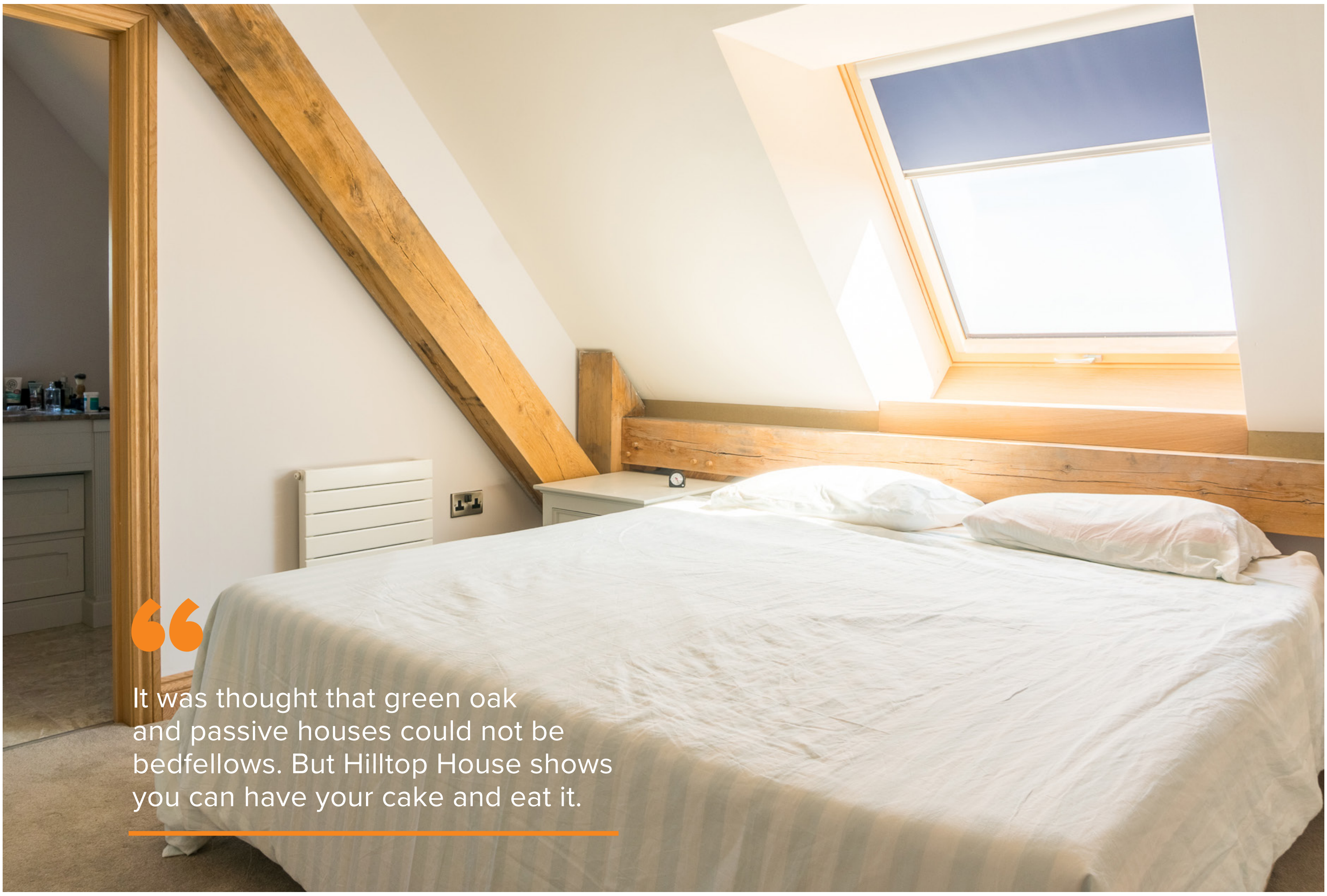
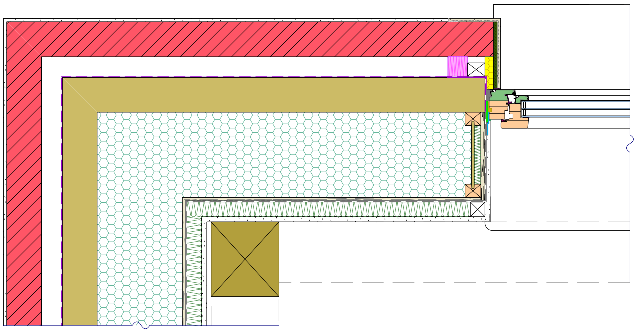


"It was thought that green oak and passive houses could not be bedfellows. But Hilltop House shows you can have your cake and eat it.



IN DETAIL

Building type: 188 sqm green oak framed passive house (+ 36 sqm garage)

Location: Hunmanby, Yorkshire

Completion date: March 2017

Cost: £450,000 (£2,008 per sqm)

Passive house certification: Passive house certified

Space heating demand (PHPP): 17 kWh/m²/yr

Heat load (PHPP): 10 W/m²

Primary energy demand (PHPP): 88 kWh/m²/yr

Heat loss form factor (PHPP): 3.16

Overheating (PHPP): 4% (of time above 25C)

Airtightness (at 50 Pascals): 0.3 air changes per hour

Energy performance certificate (EPC): A (92)

Thermal bridging: Bespoke cold bridge free junction detail design by Eco Arc certified passive house designers with input from Alan Clarke & Nick Grant.

Energy bills (measured or estimated): £305 annual gas bill for space heating, hot water and gas cooker.

Ground floor: 20mm Engineered Oak floor boards with Poly-Onx oil matt finish, on 250mm thick reinforced concrete floor slab, on Visqueen radon membrane, on 300mm thick Isoquick proprietary interlocking insulation (plus 250mm wide insulated upstand to edge of concrete slab), on 50mm small, clean, angular, free-draining stone, on formation and layering of Type 1 hard core layers back to solid substrate, proof rolled sub-grade. U-value: 0.012 W/m²K

Ground floor walls: 10mm thin coat silicone render finish by K Rend externally, followed inside by 100mm dense recycled aggregate concrete block, 50mm wide drained & vented cavity, Solitex Fronta Humida breather membrane, 100mm Gutex Multitherm wood fibre insulation, 245mm I-beam studs at 600mm c/c insulated with full-fill Thermofloc cellulose insulation, 9mm OSB board, Novia VC6 vapour control membrane, 50 x 50mm battens to form 50mm service void insulated with Knauf glass wool insulation, 12.5mm Gyproc plasterboard internal lining with plaster skim, 1 mist coast & 2 coats emulsion paint, internal exposed oak frame structure. U-value: 0.106 W/m²K.

First floor walls: Western red cedar timber cladding boards externally on 50 x 50mm cladding battens forming wide drained & vented cavity, followed inside by Solitex Fronta Humida breather membrane, 100mm Gutex Multitherm wood fibre insulation, 245mm I-beam studs at 600mm c/c insulated with full-fill Thermofloc cellulose insulation, 9mm OSB board, Novia VC6 vapour control membrane, 50 x 50mm battens to form 50mm service void insulated with Knauf glass wool insulation, 12.5mm Gyproc plasterboard internal lining with plaster skim, 1 mist coast & 2 coats emulsion paint, internal exposed oak frame structure. U-value: 0.106 W/m²K.

Flat roof: Clay tile roofing on battens and counter battens, breather membrane on soft wood apex sub frame. Flat ceiling consisting of 100mm Gutex thermal board on 2 x 300m I-beam studs at 600mm c/c with 600mm full-fill Thermofloc cellulose insulation, 9mm OSB, Novia VC6 Foil vapour control membrane, 100 x 100mm ceiling joists between oak purlins to form service void with 12.5mm Gyproc plasterboard with plaster skim, 1 mist coat & 2 coats emulsion paint. Roof U-value: 0.061 W/m²K

Pitched roof: Clay tile roofing on battens and counter battens on breather roof membrane, 100mm Gutex thermal board on 300m I-beam studs at 600mm c/c with 300mm full-fill Thermofloc cellulose insulation, 9mm OSB, Novia VC6 foil vapour control membrane, 50 x 50mm battens to form service void with 50mm Knauf glass wool insulation, 12.5mm Gyproc plasterboard with plaster skim, 1 mist coat & 2 coats emulsion paint, internal exposed oak frame structure. Roof U-value: 0.097 W/m²K

Windows: Internorm HF310 timber-aluminium triple glazed windows & HS330 sliding doors. Featuring ISO glazing spacers and glazing U-value of 0.6 W/m²K. Overall window U-value: 0.76 W/m²K.

Roof window: Fakro FTT U8 Thermo. Passive quadruple glazed unit roof lights with fivefold-sealed airtight construction, supplied complete with thermal flashing and XDK insulation kit. Overall U-value: 0.58 W/m²K

Heating system: Worcester Bosch Greenstar 12i condensing gas boiler & Worcester Bosch Greenstore TC250 twin coil cylinder total volume 190 litres, distributing heat via small radiators (generally one per room) and towel rails to wet rooms.

Ventilation: Passive House Institute certified Paul Novus 300 MVHR system. Passive house certified efficiency 93%. Electrical consumption 0.30 Wh/m³.

Green materials: Natural clay tile roofing, natural timber flooring, recycled newspaper cellulose insulation, FSC timber. ■

PASSIVE SHELTERED SCHEME

500 YEARS IN THE MAKING

Taking its cues from the original historic almshouse on site, St John's Lichfield chose to build their new sheltered housing development for older persons to the passive house standard as part of high-quality design that emphasised community, calm and comfort.

Words by John Cradden

£110

per apartment per year for space heating

Building: Cavity-wall apartment blocks providing sheltered accommodation

Location: Lichfield, Staffordshire

Completed: August 2017

Budget: £4.25m

Standard: Passive house certified

“

Because the original St John’s was innovative in its time, we wished to replicate this and build something modern that we could all be proud of.

The decision by St John’s Lichfield, an English charitable trust that provides sheltered accommodation, to choose the passive house standard for a new sheltered residential scheme for older persons looks to be a solid continuation of an innovative, forward-thinking ethos that dates back several centuries.

The new development that adds to the historic St John’s Almshouse complex provides for 18 new apartments contained within three separate buildings, which are arranged around a new landscaped courtyard. They were designed to create a second quadrangle that mirrored the existing quadrangle, which contains the original grade-one listed almshouse that was built in the late 15th Century.

“We wanted the building to be efficient as residents are elderly and often with limited means, and because the original St John’s was innovative in its time, we wished to replicate this and build something modern that we could all be proud of,” says Katherine Duncan-Brown, chair of the St John’s Lichfield board of trustees.

The roots of the original St John’s Almshouse stretch back as far as 1129, when a priory was built outside the midlands city of Lichfield as a hostel for poor pilgrims who had come from many miles away to worship at the shrine of Chad, the first bishop of Lichfield.

In 1495, Bishop William Smythe re-founded the priory as an almshouse for nine men “who through no fault of their own had fallen on hard times”. This entailed a rebuilding project that was considered ground-breaking in its day. The grade-one listed Tudor brick buildings are now nationally famous for their chimneys, which were among the first domestic chimneys in the Midlands.

Until the decision in 2013 to commission the new apartments, the existing complex provided 24 apartments for 31 residents, so the scheme represents a significant expansion both in accommodation and in the number of residents.

The trust commissioned Worchester-based KKE Architects, who specialise in healthcare design, to design the new complex.

KKE suggested the passive house approach to the trust at interview stage, and it clearly appealed on a number of levels, according to lead architect Lorin Arnold. This included the high-quality of materials and design, but also the prospect of comfort and low running costs for residents, who pay their own utility bills.

But besides passive house principles, the overall design was informed more by the existing context and the idea of creating a new communal courtyard and pavilion, says Arnold. “These are the heart of the scheme both formally and socially, with the accommodation in two perpendicular blocks enclosing two sides,” he says.

The circulation areas (access walkways, stairs and lift areas) form a semi-private space that also faces onto the courtyard, while the balconies and terraces face outwards towards the perimeter of the site. “This mix of private, semi-private and communal spaces helps to reinforce the sense of community which has been established at St John’s over centuries.”

The new development also incorporates

Surface area to volume ratio is a measure of how compact a building is. In passive house design, it is often expressed as the 'heat loss form factor', which is the ratio for the external surface area of the building to the treated floor area.

The higher the figure, the less compact the building, meaning there is more surface area from which heat can escape, making it more difficult to meet the passive house standard.

Photography: *Nick Caville*

high quality materials designed to blend into their environment, including hand-made bricks, clay plain roof tiles, copper cladding and green oak framing, with design cues taken from the use of oak in the original buildings.

"The use of these high-quality materials not only contributed to an aesthetic suitable for a conservation area, but also coupled with the high levels of workmanship required by passive house, should ensure the durability and longevity of the buildings for future generations of residents," says Duncan-Brown.

The new apartment blocks are of cavity wall construction with full-fill insulation to the cavities. There is one block of 14 one-bedroom apartments, and then two smaller blocks with two two-bed apartments each, but these ▶

are in fact connected by a roof structure and insulated walkway, so they effectively appear as one building.

"Longevity and robustness were key factors with the existing buildings that date from 1495, so the client was keen to ensure the new buildings were built to last — traditional cavity wall construction made sense from this perspective, and with the use of brick elevations," says Arnold.

The smaller blocks required more insulation to meet the passive house standard because of higher surface area to volume ratios, but there were also major headaches in achieving the necessary airtightness for the entire development, according to the project's passive house designer, Dr Sarah Price of Design Buro.

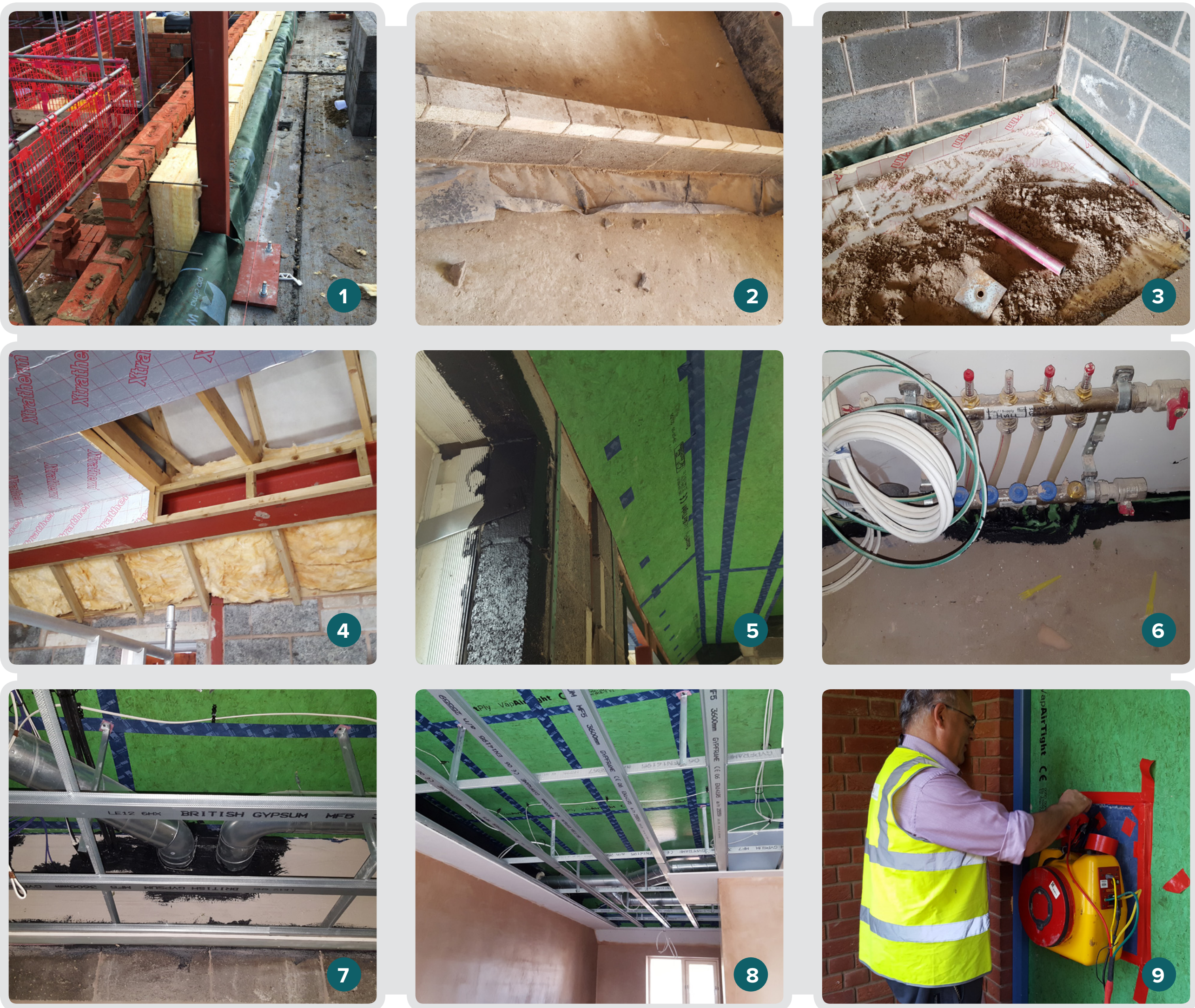
Initially, the idea was to have the primary airtightness envelope around the external walls of the three blocks. However, there were major failures when the smaller blocks were tested.

"The airtightness layer failed at internal floor junctions where the concrete slabs had been laid on the membrane," says Price. There was also no airtightness coordinator employed by the original contractor, who went into administration during the build, and as a result many of the airtightness details were missed, according to Price.

Areas of the blockwork wall above the ceiling void were not rendered (the render intended to be the airtightness layer here), and airtightness membranes behind internal partition walls were omitted.

The airtightness strategy was changed so that each apartment was made individually airtight, bringing the airtight layer within

CONSTRUCTION IN PROGRESS



1 Wall build-up features brick outer leaf, followed inside by Isover mineral wool & Ancon TeploTie thermal wall ties in wall cavity, and Hemelite block internally; **2** thermal blocks in foundations where party wall causes a break in the insulation layer; **3** Xtratherm Thin-R insulation below and around edges of floor screed, and damp-proof membrane under this, which also serves as the airtightness layer here; **4** Xtratherm Thin-R insulation to underside of ceiling build-up, with Isover Spacesaver Plus above this to floor of attic above; **5, 6 & 7** Blowerproof liquid airtight paint and Smartply ProPassiv (formerly VapAirTight) airtight OSB board formed key components in the airtight envelope, with Pro Clima tape; **8** taping of the ProPassiv board at underside of ceiling, with service cavity below this; **9** the blower door tests by Paul Jennings produced average results per dwelling of 0.48 and 0.56 air changes per hour at 50 Pascals for the large and small blocks respectively.

the units. As such, all airtightness junctions became accessible again, with the primary airtightness layer formed by membranes behind internal walls and floors, internal plaster to the external walls, Smartply ProPassiv airtight board to top-level ceilings, and the pre-cast concrete slabs to intermediate ceilings.

But significant remedial work was also required, and specialist airtightness contractor ECO DC was brought in to make sure the apartments met the passive house standard of 0.6 air changes per hour. As well as new taping the team also made liberal use of Blowerproof liquid airtight paint.

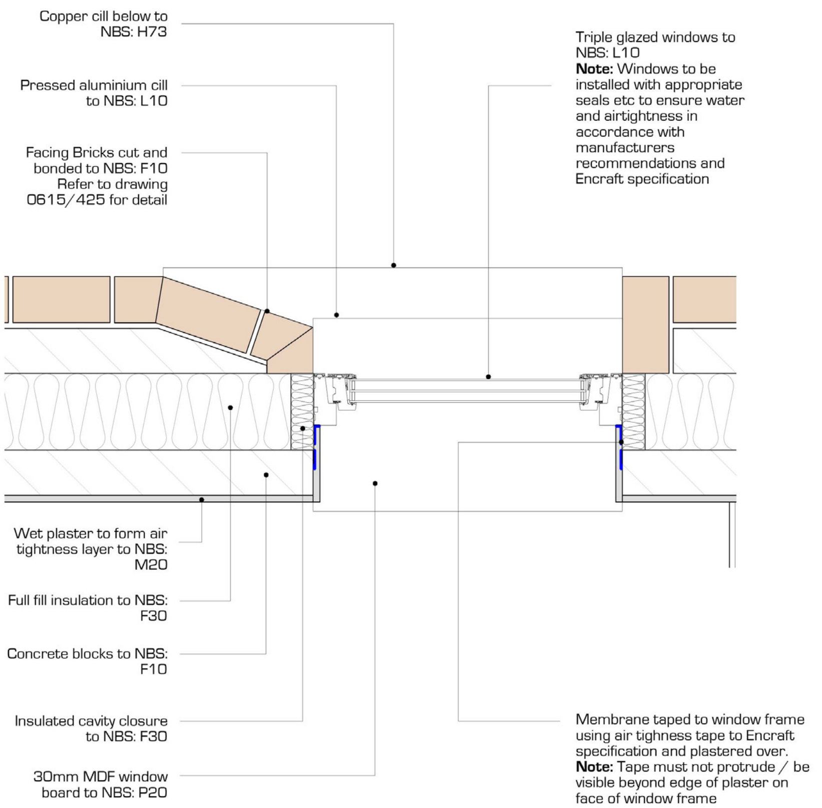
"My main hope is that others will learn from this project and see the value in employing a dedicated airtightness coordinator," Price says.

Another issue was the delays caused by the discovery of 48 medi-eval skeletons during excavations. And although a centralised Worchester gas boiler now serves the whole complex and a central heat recovery unit looks after ventilation duties for the larger block of 14 apartments, individual heat recovery ventilation systems were specified for the smaller block.

"In effect, the heat losses of the building are reduced so much that it hardly needs any heating at all. Energy bills will be minimal, thereby removing a significant worry for many older people on lower incomes," says Duncan-Brown. She also states that the new almshouses are a great example of how older people's lives can be fulfilled and enriched by their surroundings. Lorin Arnold, meanwhile, is mostly happy with how well proportions of the courtyard work and, along with the quality of the materials, the existing oak tree and the orientation of the buildings "helps create a really calm and restful environment for the residents," he says.

"The covered walkways also act as more than just circulation spaces; they have a beautiful outlook over the courtyard, as well as providing incidental meeting points where people can socialise informally — this social aspect was key to the original design concept and it's great to see the buildings in use now and hear positive feedback from the residents."

> But there were major headaches in achieving the necessary airtightness for the entire development.



SELECTED PROJECT DETAILS

Client: St John's Hospital
Client advisor: Greenwood Projects
Architect: KKE Architects
Passive house consultant: Design Buro
Project manager: Oldminster Properties
M&E engineer: Encraft
Civil & structural engineer: Mark Brock Consulting Engineers
Quantity surveyor: Greenwood Projects
Mechanical contractor: Orrell Heating & Plumbing
Airtightness tester: Paul Jennings (Aldas)
Airtightness contractor: Ecological Design & Construction (ECO DC)
Liquid airtightness membrane: Blowerproof (via Ecomerchant)
Airtight OSB: Smartply
Windows & doors: Nordan
Gas boilers: Worcester Bosch
MVHR: Swegon
Low thermal conductivity wall ties: TeploTie (via Ancon)
Rigid PIR insulation: Xtratherm
Structural insulated blocks: Foamglas
Mineral wool insulation: Isover
Cavity closers: Cavalok
Concrete blocks: Hemelite, via Tarmac

WANT TO KNOW MORE?

The digital version of this magazine includes access to exclusive galleries of architectural drawings.

The digital magazine is available to subscribers on www.passive.ie


IN DETAIL

Building type: 18 apartments split into three blocks totalling 1,057 sqm treated floor area. The larger block is comprised of 14 one-bedroom apartments at 55 sqm each, while the two identical smaller buildings each contain two two-bed apts at 68 sqm each. Cavity wall construction.

Location:
St John's Hospital, Lichfield, Staffordshire

Completion date: August 2017

Budget: £4,250,000

Passive house certification: Certified

Space heating demand (PHPP): 9 kWh/m²/yr (block of 14), 10 kWh/m²/yr (blocks of 2)

Heat load (PHPP):
10 W/m²K (block of 14), 11 W/m² (blocks of 2)

Primary energy demand (PHPP): 86 kWh/m²/yr (block of 14), 117 kWh/m²/yr (blocks of 2)

Heat loss form factor (PHPP):
2.09 (block of 14), 3.06 (blocks of 2)

Overheating (PHPP):
1.2% (block of 14), 0.0% (blocks of 2)

EPC: C (79 kWh/m²/yr) for the 14-apartment block & B (84 kWh/m²/yr) for the blocks of 2.

Airtightness (at 50 Pascals): Average of 0.48 (block of 14) and 0.56 (blocks of 2) per unit.

Thermal bridging:
The cavity wall building achieved thermal bridge free design, with only a few thermally broken balcony connectors being modelled in the PHPP.

External wall to floor: Structural insulated block (Foamglas Perinsul) used in internal leaf of blockwork at external wall-to-floor junction to allow for continuous line of insulation.

Intermediate floor to external wall:
Intermediate floors supported by internal blockwork leaf so as not to bridge insulation layer.

Cavity wall: Low conductivity basalt cavity ties (Ancon TeploTie) used.

Window to external wall: Structural insulated cavity closers (Cavalok BigBlok) used to support windows. Double lintels used on inside and outside leaf to avoid thermal bridges.

Energy bills (measured or estimated):
Estimated average of £19.61 per apartment per year for space heating only, based on average apt size, space heating demand figures above, gas price of 3.8p per kWh and taking boiler efficiency into account. Also estimated annual standing charge for gas of £90.41 per apartment, for total bill of £110.17. Calculations from uswitch.com.

GROUND FLOOR
Block of 14: 80mm screed, followed beneath by 30mm Xtratherm Thin-R, 125mm Xtratherm Thin-R, DPM (airtightness layer), 150mm in-situ concrete slab, DPM. U-value: 0.135 W/m²K
Blocks of 2: 80mm screed, 30mm Xtratherm Thin-R, 175mm Xtratherm Thin-R,DPM (airtightness layer), 150mm in-situ concrete slab, DPM U-value: 0.103 W/m²K

WALLS
Block of 14: 100mm brick outer leaf, followed inside by 170mm Isover mineral wool to fully fill wall cavity, 100mm Hemelite block, 13mm plaster. U-value: 0.169 W/m²K

Blocks of 2: 100mm brick outer leaf, followed inside by 200mm Isover mineral wool to fully fill wall cavity, 100mm Hemelite block, 13mm plaster. U-value: 0.169 W/m²K

ROOF (insulated at ceiling level)
Block of 14: Clay plain roof tiles externally, followed underneath by timber trussed rafter (cold roof), 150mm Isover Spacesaver Plus on loft floor, 65mm Xtratherm Thin-R, SmartPly ProPassiv board taped at joints, MF suspended ceiling contained 200mm services void, plasterboard skimmed & painted.
U-value: 0.165 W/m²K
Blocks of 2: Clay plain roof tiles externally, followed underneath by timber trussed rafter (cold roof), 250mm Isover Spacesaver Plus on floor of loft, 65mm Xtratherm Thin-R, SmartPly ProPassiv board taped at joints, MF suspended ceiling contained 200mm services void, plasterboard skimmed & painted.
U-value: 0.116 W/m²K

Windows: Nordan Ntech tilt & turn triple glazed timber windows. Overall U-value: 0.83 W/m²K. Nordan Ntech external doors.
Overall U-value: 0.7 W/m²K

Heating system: Centralised Worcester Logamax 61kW gas boiler with SPF of 92% supplying SAV Series 7 fully insulated heat exchanger units in each apartment, for underfloor heating systems and domestic hot water.

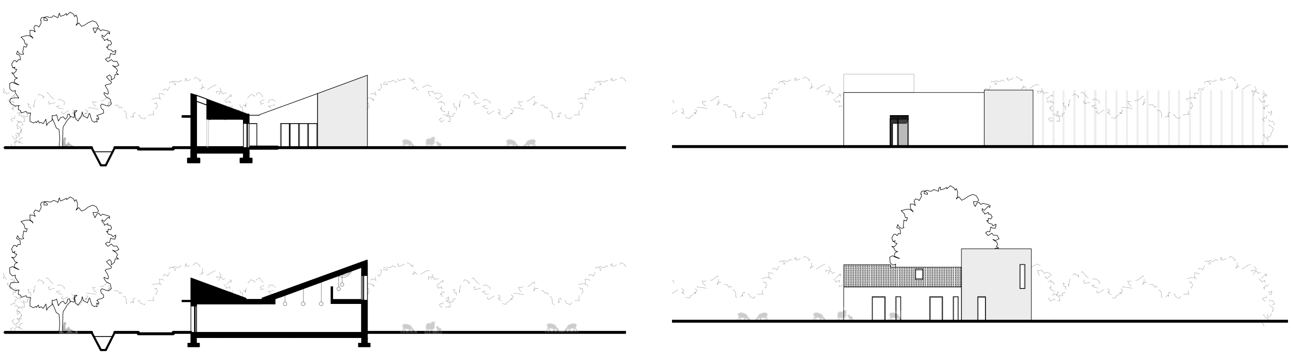
Ventilation: Centralised Swegon GOLD RX Series heat recovery ventilation system, PHI Certified to have heat recovery rate of 84%, to supply block of 14 apartments. Individual Paul Focus 200 heat recovery ventilation units, PHI Certified to have heat recovery rate of 91%, to supply smaller blocks.

■

HOME FARM

While a tight budget meant some of the more ambitious eco features planned for this simple and graceful new farmhouse had to be dropped, it still manages to meet Ireland's standard for nearly zero energy buildings (nZEBs) thanks to a combination of superb detailing and fabric-first design.

Words by Ekaterina Tikhoniouk



€80

costs per year
(calculated space heating)

Building:
109 sqm cavity wall house

Location: Kildalkey, Co Meath

Completed: February 2017

Standard:
Nearly zero energy building (nZEB)

Situated in the quiet countryside of Kildalkey, close to the historic town of Trim, the sleek profile of Susan McNamara's modern, very low energy house contrasts the grand, blocky form of her childhood home – the 200-year-old Cloncarneel House situated just across the road from her new build.

Designed by Cooney Architects, the new house sits beautifully into the rural landscape. Surrounded by hedgerows and sheep, it evokes an old whitewashed farmhouse aesthetic, while also delivering modern spoils such as excellent indoor air quality, thermal comfort and low energy bills.

Despite being on a tight budget, McNamara wanted "something different to the standard bungalows you'd see, but that would fit in with the countryside" and so, according to Frank Cooney, the director overseeing the project in Cooney Architects, "the design was based on an analysis of traditional building forms and materials in the Irish landscape, and reinterpreting these in the context of a contemporary house".

And, despite its unusual profile and sleek aesthetic, the design that emerged fits beautifully into the Meath landscape. The house consists of two sloping volumes that interlink, forming two courtyards at their junctions. One volume houses a light-filled, open-plan living and kitchen space with a mezzanine, and an office space that also acts as a boot room, while the other volume contains two bedrooms and a bathroom. The design also includes ingenious built-in storage spaces.

McNamara wanted a house "that was sustainable and healthy to live in and had a low impact on the environment." And while meeting the passive house standard or Ireland's proposed standard for nearly zero energy buildings (nZEB) was never part of the brief, McNamara was keen to follow passive house design principles as much as possible.

"We would have analysed the house from day one in terms of its site, materials, and energy," Frank Cooney says. "We started off using a lot of pre-set sustainability criteria." A lot of this had to be removed due to the tight budget, however.

But the house still manages to achieve superb energy efficiency (see boxout). It is also sustainable in a visual sense, adding to rather than subtracting from the landscaping, making it an elegant and subtle contrast to the McMansions that blight plenty of rural areas in the Dublin commuter belt.

The house is of an insulated cavity block wall construction and, according to Frank Cooney, the team "started off wanting to use a lot of healthy materials, looking at specifying products like cellulose insulation, natural insulating materials." He adds: "But those got taken out later on."

When it came to the ventilation strategy McNamara opted to install an Aereco demand-controlled mechanical extract system, as opposed to heat recovery ventilation — again it was a more budget friendly option.

But having grown up in an old house with a traditional stove, she was adamant about putting in a wood-burning stove in her new build. The stove supplements the building's main space heating system, which consists of an air source heat pump with underfloor heating. The house is also plumbed for future installation of solar thermal panels.

McNamara is delighted to be living in her "beautiful, bright, fresh and modern home". "I feel connected with nature, with countryside views from every room," she says.

She has also noticed the health benefits of her new, well-ventilated home. "The new house makes a huge difference in terms of asthma and allergies. It's much healthier, and the Aereco system is constantly drawing in fresh air throughout the house," she explains. "I used to suffer much more with allergies in my old home."

Comfort-wise, she says the new house is incomparable to her grand but drafty childhood home. "It's a different world," McNamara states. "It's lovely stepping out of bed in the morning and the floors are heated. It's just amazing, really comfortable to live in." She adds: "And the energy bills are so low, it's really phenomenal."

> The design was based on an analysis of traditional building forms and materials in the Irish landscape, and reinterpreting these in the context of a contemporary house.

AN UNORTHODOX NEARLY ZERO ENERGY BUILDING

While Susan McNamara's home initially fell short of Ireland's proposed standard for nearly zero energy buildings (nZEBs) — which all new dwellings must meet from 2021 — an updated assessment obtained by Passive House Plus puts the house within the nZEB criteria.

The initial building energy rating (BER) calculation, performed by BM Energy Consultants, gave the house an A3 BER (71.74 kWh/m²/yr) and an energy performance co-efficient (EPC) of 0.327. Dwellings must achieve an EPC lower than 0.3 to be deemed nZEBs according to Ireland's proposed standard – with 0.3 meaning 30% of the energy demand of a home built to the 2005 building regulations.

However, this initial calculation used a default thermal bridging factor of 0.08 W/m²K. A fresh thermal bridging calculation obtained by Cooney Architects from the consultancy Passivate, based on the dwelling's as-built details, reduced the thermal bridging factor to 0.0215 W/m²K.

This in turn pushed the EPC down to 0.285, within the nZEB standard, with the primary energy demand dropping to 62.17 kWh/m²/yr — still an A3 BER, but a much better one.

If the house had been built to exactly meet the 0.3 EPC target for nZEBs, its primary energy target would have been a mid A3 BER of 65.44 kWh/m²/yr – a surprising finding, given the Irish government has indicated that the nZEB standard should equate to approximately 45 kWh/m²/yr primary energy consumption for a typical dwelling.

The reason is fairly simple: it's the form factor. Susan McNamara's home has an architecturally-expressive design, featuring double height spaces and an L-shaped floor plan, adding up to a large amount of surface area relative to the floor area – surfaces through which heat can escape. This result also suggests that at least for some dwelling types, achieving nZEB may not be as difficult as previously thought.

Simple construction, executed well

Thermal bridging expert Andy Lundberg of Passivate praised the thermal bridging details designed by Cooney Architects for Susan McNamara's home. In correspondence with Passive House Plus, he explained:

"The junctions themselves are quite simple, albeit robust, in that it's cavity wall construction with full-fill bonded bead, plus internal insulation, so there's nothing new there. There is a warm roof construction and the floor build-up would also be considered standard. There is use of some Quinn Lite thermal blocks but that's it, there are no other special thermal breaks used.

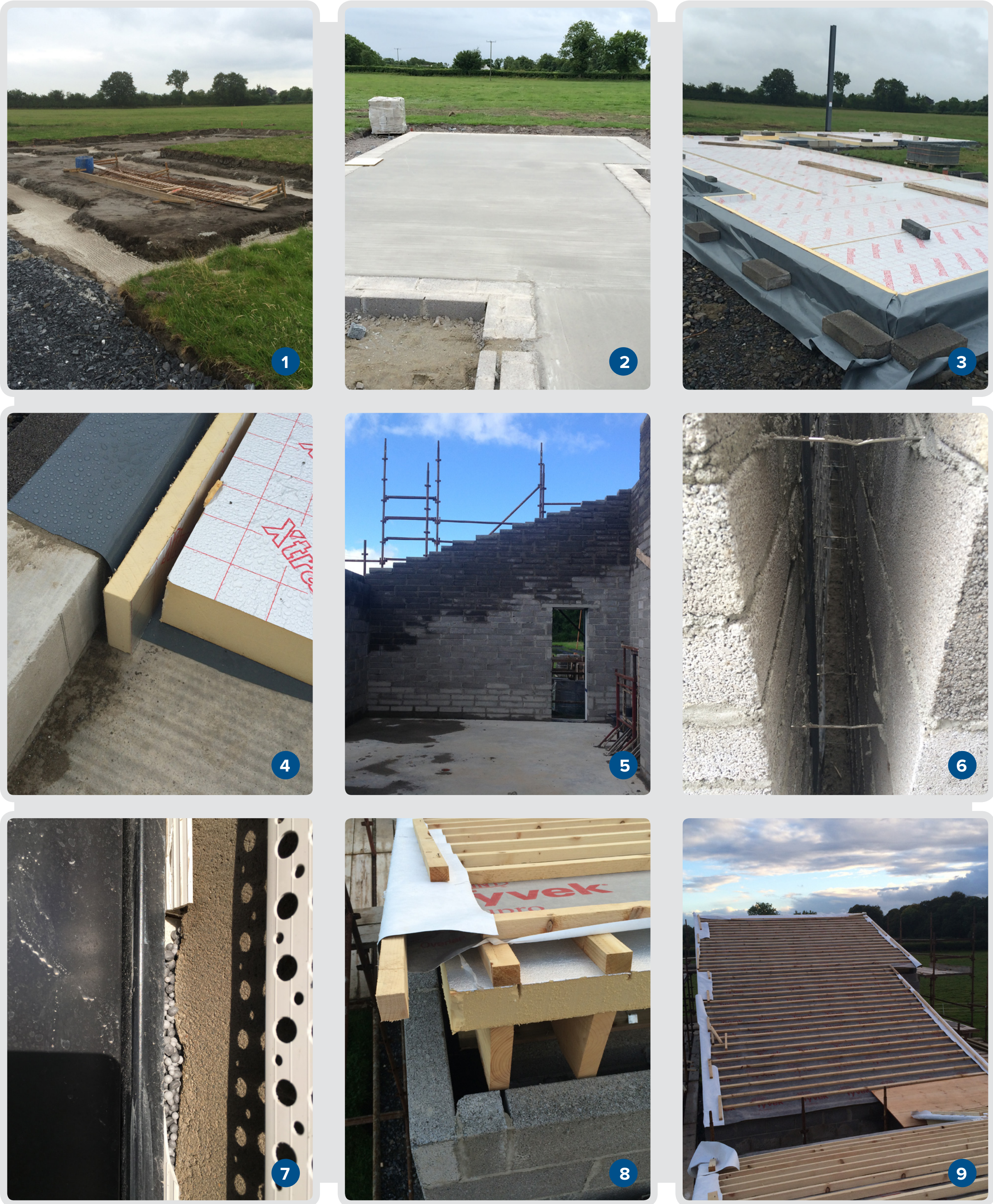
"So that's what's best about it — simple construction executed well, with good thicknesses of insulation carried across junctions, and careful airtightness detailing. All this means the performance gap [the difference between designed and real-world performance] is likely to be close to zero in those areas — which is far more important than designing buildings and junctions with incredible performance that are, however, difficult to execute on site.

"Looking at the building envelope, one might argue the form of the building is less than ideal from an energy efficiency point of view, and this is true. However, as individual blocks the forms are relatively efficient.

"Also, purely from a y-factor [thermal bridging factor] point of view, the fact the building has a high surface area to volume ratio means heat losses from thermal bridging area are weighted over a larger area, and therefore the y-factor reduces. So interestingly, the most efficient built form does not necessarily lend itself to a low y-factor. Indeed, the opposite can sometimes be the case."

Photography: Donal Murphy

CONSTRUCTION IN PROGRESS



1, 2 & **3** Work begins on the foundations and ground floor build-up, featuring a 150mm concrete slab followed above by 150mm Xtratherm insulating board; **4** there is also 50mm insulation to perimeter, and Quinn Lite thermal blocks at the wall-floor junction to reduce thermal bridges; **5** construction of the cavity walls reaching completion; **6 & 7** the 150mm wall cavities before and after being fully filled with bonded-bead insulation; **8** the roof build-up with Tyvek Supro breather membrane over 100mm Xtratherm Thin-R (the 200mm rafters below this were then insulated with Isover Metac quilt insulation); **9** construction of monopitch roofs almost complete, with timber battens above the Tyvek breather membrane waiting to receive roof slates.

Demand-controlled ventilation systems typically employ fans that extract air through humidity-sensitive grilles in "wet rooms" (kitchen, bathrooms etc), with fresh replacement air drawn through humidity sensitive air inlets in "dry rooms" (bedrooms, living rooms). The use of humidity sensors ensures the air is only changed when the rooms are occupied, helping to save energy.

ENERGY COSTS EXPLAINED

Susan McNamara's total energy bills have averaged a parsimonious sum of €80 per month – totaling €955 per year for all uses – heating, hot water, lighting and all household electricity use. But how do the figures in the Deap calculations compare to real usage for this nZEB?

A comparison is made tricky by the fact Deap ignores all so-called unregulated energy use – namely the plug loads for white goods, TVs, phone & laptop chargers, etc. But the figures in Deap appear fairly close to actual usage.

Assuming 50/50 use of a day and night rate meter, and competitive tariffs of 0.1680c day rate and 0.0830c night rate, the house's total regulated usage would come out at roughly €380/yr – including €78/yr for the tiny calculated demand of 618 kWh/yr for the primary space heating system. McNamara's free wood supply means savings of roughly €50/yr on fuel for the calculated 490 kWh of heat from the wood stove. The remainder is made up of a calculated €210 for hot water, €65 for lighting and €30 for pumps and fans. A standing charge of €344 would bring the total bill up to €915/yr. If those figures are reflected in reality, it leaves €228 for all plug loads, suggesting a fairly low usage of less than 2,000 kWh/yr.

Airtightness detailing showing: **1** taping where services are embedded in the cavity wall chases; **2** airtightness detailing around ventilation ductwork in the roof, and Alfa Rufol airtight vapour barrier to underside of the roof build-up; **3** taped junction between the Alfa Rufol membrane and internal wet plaster, both of which form key elements of the airtight envelope.

> It is also sustainable in a visual sense, an elegant and subtle contrast to the McMansions that blight plenty of rural areas in the Dublin commuter belt.

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Foundation Riser

Xtratherm floor and foundation detailing that achieves NZEB thermal targets with guaranteed structural integrity without the need for engineering calculation.

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- U-values achieved 0.11- 0.15 W/m^{2}k
- Suitable for multi storey buildings with a high compressive strength of 7.5N/mm^2 and 13N/mm^2
- Complies with standard construction ACDs
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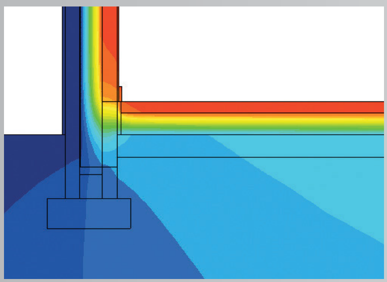
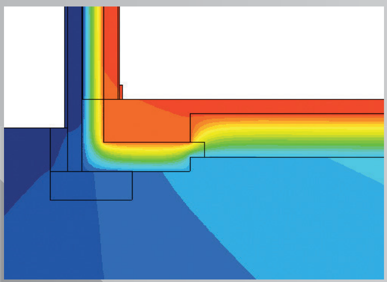
Innovative Products

CavityTherm Riser

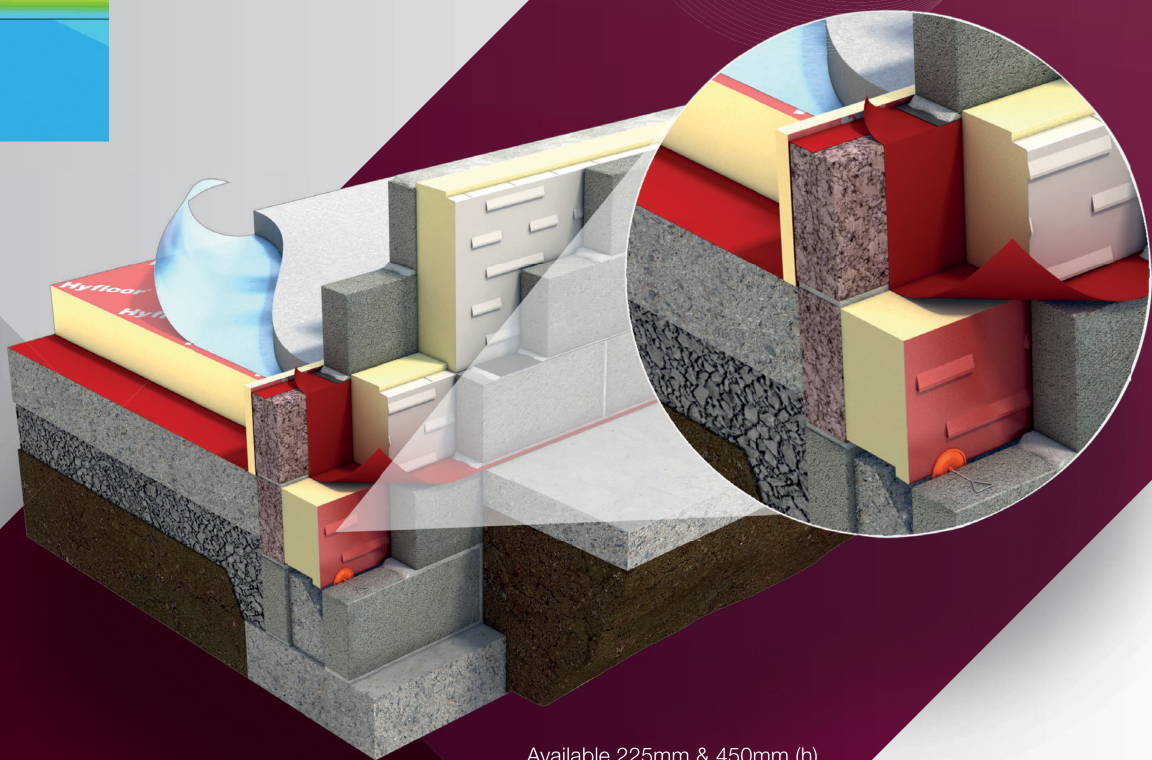


PSI Value = 0.076

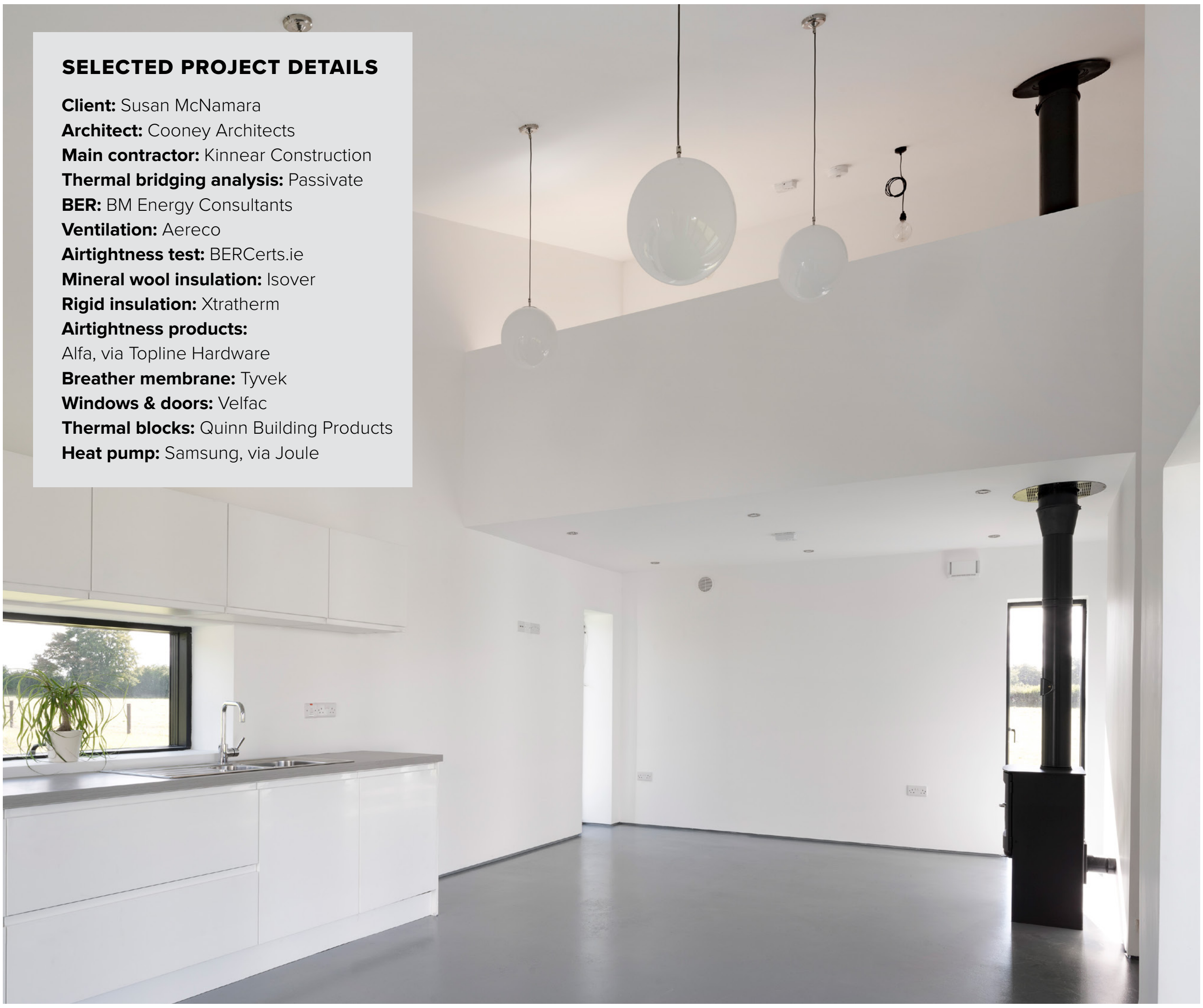
Typical EPS Foundation System



PSI Value = 0.105



Available 225mm & 450mm (h)



SELECTED PROJECT DETAILS

Client: Susan McNamara
Architect: Cooney Architects
Main contractor: Kinnear Construction
Thermal bridging analysis: Passivate
BER: BM Energy Consultants
Ventilation: Aereco
Airtightness test: BERCerts.ie
Mineral wool insulation: Isover
Rigid insulation: Xtratherm
Airtightness products:
Alfa, via Topline Hardware
Breather membrane: Tyvek
Windows & doors: Velfac
Thermal blocks: Quinn Building Products
Heat pump: Samsung, via Joule

> This result also suggests that at least for some dwelling types, achieving nZEB may not be as difficult as previously thought.

Nearly zero energy building (nZEB) is a new EU standard that all new dwellings must meet from 1 January 2021. Each EU member state has been given a certain amount of leeway to define its own nZEB standard. In Ireland, dwellings will have to achieve an energy performance co-efficient (EPC) of 0.3 or less to be deemed nZEBs.

The EPC is an overall measure of the energy efficiency of a dwelling which takes into account its insulation levels, airtightness, building form, thermal bridging, heating systems and more. The EPC is defined against the 2005 regulations, so a building with an EPC of 0.25 consumes, in theory, 25% of the energy of one built to the 2005 regulations.

IN DETAIL

Building type:
109 sqm detached cavity wall house

Location: Kildalkey, Co Meath

Completion date: February 2017

Budget: Under 4,500 kWh of metered electricity use per annum.

Energy performance coefficient (EPC): 0.285

Carbon performance coefficient (CPC): 0.249

BER: A3 (62.17 kWh/m^2/yr)

Measured energy consumption: N/A

Airtightness (@ 50 Pascals pressure): 0.52 air changes per house / 1.492 m^3/hr/m^2

Thermal bridging: Quinn Lite block to inner leaf where cavity wall meets the foundation, low thermal conductivity wall ties

Energy bills (measured or estimated): Average of €80 per month for electricity (covering primary space heating, hot water and all electrical use) according to correspondence with the client. Free supply of wood for the stove from fallen trees.

Ground floor: 75mm screed incorporating underfloor heating, over 150mm Xtratherm Xt/UF insulating board, over 150mm concrete slab. U-value: 0.12 W/m^{2}K. 50mm insulation to perimeter.

Walls: Sand & cement render externally on 150mm external leaf concrete blockwork, on 150mm cavity fully filled with bonded-bead insulation, on 100mm internal leaf blockwork, with 82.5mm insulated plasterboard internally. U-value 0.12 W/m^{2}K

Roof: Fibre cement roof slates, on 50mm x 50mm treated timber battens, on Tyvek Supro breather membrane, on 100mm Xtratherm Thin-R board over rafters, on 200mm rafters insulated with Isover Metac quilt insulation, with Alfra Rufol Vario vapour control membrane to underside. U-value: 0.11 W/m^{2}K

Windows: Velfac 200 Energy triple glazed timber alu-clad windows. U-values: 0.88 to 0.95 W/m^{2}K. Velfac timber alu-clad door with overall U-value of 0.76 W/m^{2}K

Heating system: Samsung 12kW air-to-water heat pump supplying underfloor heating, via Joule Smart Plumb 340L cylinder integrating buffer tank and hot water cylinder. Dik Geurts Ivar 8 wood-burning stove with heat output up to 10kW.

Ventilation: Aereco humidity-sensitive demand-controlled ventilation system.

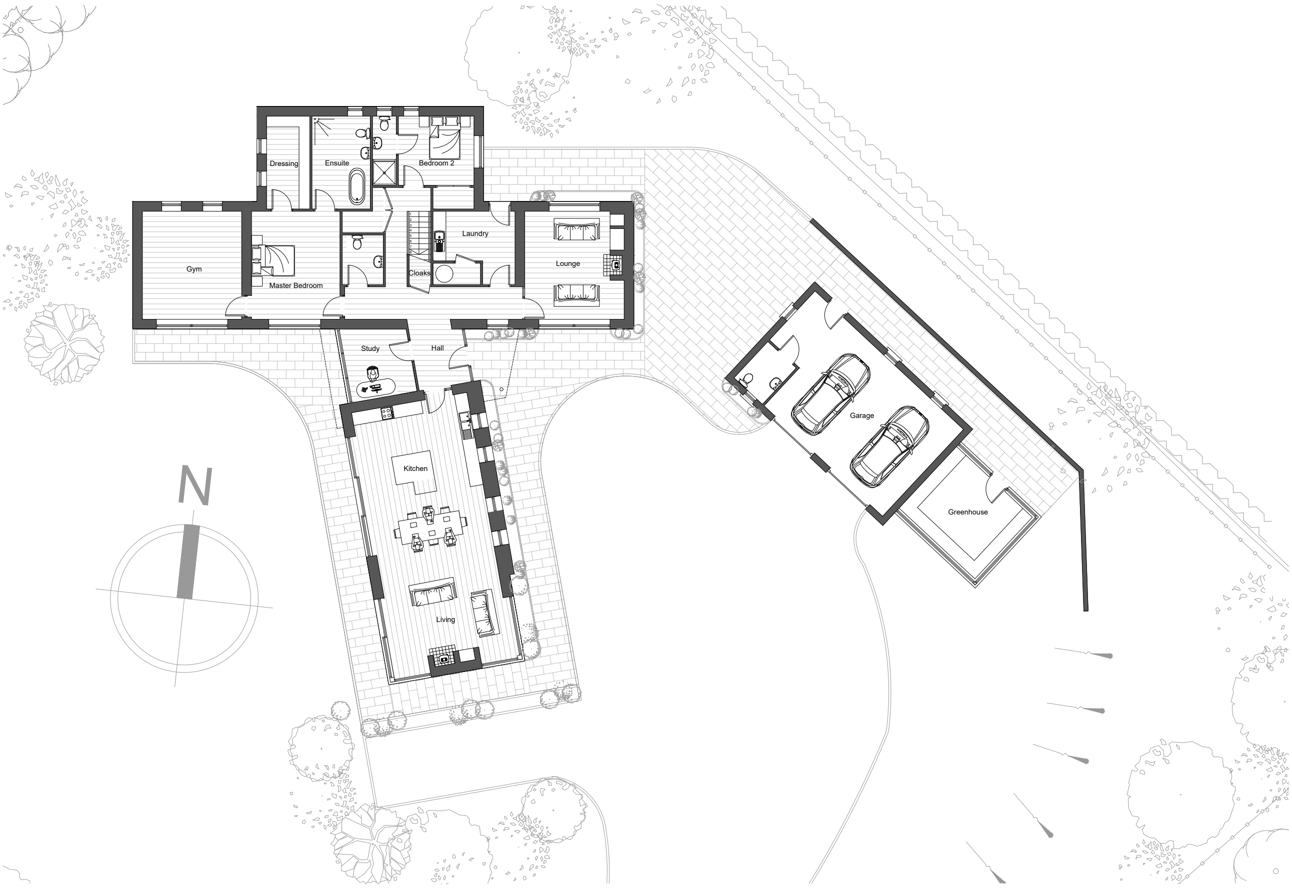
€120
costs per year
(calculated space heating)

Building: 302 sqm cavity wall house
Location: Portadown, Co Armagh
Completed: August 2017
Standard: Passive house certified

ARMAGH PASSIVE HOUSE
HIDES IN PLAIN SIGHT

A new family home in County Armagh blends together a traditional, clustered farmhouse style and a modern aesthetic so seamlessly, you would never even guess it's a certified passive house.

Words by Jason Walsh



Summerisland in County Armagh is the expression of an idea that has taken shape over the years in the pages of this very magazine: the passive house as an ideal family dwelling. Situated on a rural site just west of Portadown, the plan was to, at once, resemble a traditional cluster of Irish farm buildings, while also offering a contemporary and light-filled living area – all while meeting stringent energy targets.

As a result, some unusual design decisions were taken, with the building taking on a near-cruciform shape, complete with vaulted ceilings and multiple sections. The payoff is that the house somewhat differs from the traditional passive house form. It's much easier to meet the standard with simpler shapes, fewer tricky junctions to insulate and seal, and as little surface area as possible through which heat can escape. The house's designer Paul McAlister, principal at Paul McAlister Architects in Portadown, County Armagh, says that one of the main goals was to match an elegant modern design with the low energy demand of a passive house.

"We hope it's a nice elegant house and an attractive piece of architecture that also has low energy performance," he says.

When it came to the design — high ceilings and a mixture of the old and new — inspiration came from close to home: the roof forms in particular, with their change in eaves heights, are reminiscent of a traditional rural cluster.

"The concept of the design was the layout of traditional farmhouse buildings. Our practice is in the countryside; I'm from a farm myself," says McAlister. "I like to have houses within the reach of ordinary people."

Designed with wheelchair accessibility in mind, almost everything is on the ground floor, with only guest bedrooms on the first floor. Glazing – consisting of large expanses of high performance Internorm triple glazed windows and doors – is positioned to the east, south and west side of the main living area.

"In the main kitchen-dining-living space, it gives you a lovely vaulted feeling. You get the notion that it's a rural cluster of barns, and yet it's contemporary," he says.

Summerisland is McAlister's second fully-certified passive dwelling – though his 455 sqm home for The Centre for Renewable Energy and Sustainable Technologies (CREST) at South West College in Enniskillen was also certified – but in this case the idea of a passive house case came as much from the client as from the architect. Nonetheless, McAlister is a veteran of the passive house movement at this stage — he was the first person in Northern Ireland to become a certified passive house designer back in 2010.

"I was personally very interested in it, maybe for techy, anorak reasons, but there was no demand for it back then." But that has started to change, as his growing practice bears out.

"The passive house system relies on five elements: insulation, airtightness – which is the most difficult thing for a builder to achieve on-site – high quality windows and doors, thermal bridge detailing of the

> I'm from a farm myself. I like to have houses within the reach of ordinary people.

elements, and ventilation, in this case with heat recovery," he says.

"The client came specifically to us looking for a passive house. It was my second certified one, and we've just finished another, and also done a [passive standard] school. It's the first passive certified education building in Northern Ireland. We've also done another five [dwellings] that would meet the certification," he says.

Asked how he came to design a house that is out of step, in terms of building form, with what we traditionally conceive of as a passive house, McAlister says that there is no reason to avoid aesthetic experimentation if the technical side of the design and construction is properly carried out. The demand for a house that conserves energy does not necessarily require a simple cuboid shape.

"My personal view is, within reason, you design the house you want—south-facing windows help obviously, but people want those anyway. Nearly any building can be made passive, even north-facing ones, which is something that people [often] don't appreciate."

Summerisland's blockwork construction is another interesting factor. The build method here is about as conventional as it could possibly be: cavity wall construction sitting on a strip foundation. Wall insulation is full-fill polystyrene bead with boards used only in the floor and ceiling.

"It's a traditional block with a very wide cavity," says McAlister. "The solidity of the thing is quite nice, and you have good sound-deadening between rooms. It also has a small advantage in terms of thermal mass."

It's a case of horses for courses, he says. "Sometimes you get a client who has a serious ecological bent who only wants natural materials, and sometimes they are concerned more with performance."

Having been elected in 2017 as chairman of the Passive House Association of Ireland, McAlister is also interim co-chairman of nZEB Ireland, a new independent body set up to help ensure that Ireland doesn't fall short in implementing the EU's mandated nearly zero energy building standard. So, it was befitting that McAlister commissioned BER assessors IHER to check how Summerisland fared relative to Ireland's proposed nZEB definition, even though it will not apply in Northern Ireland. The house blitzed the requirement, reaching an Energy Performance Coefficient of 0.138 – an 86.2% energy reduction on the 2005 build specs that Ireland's regs use as a benchmark.

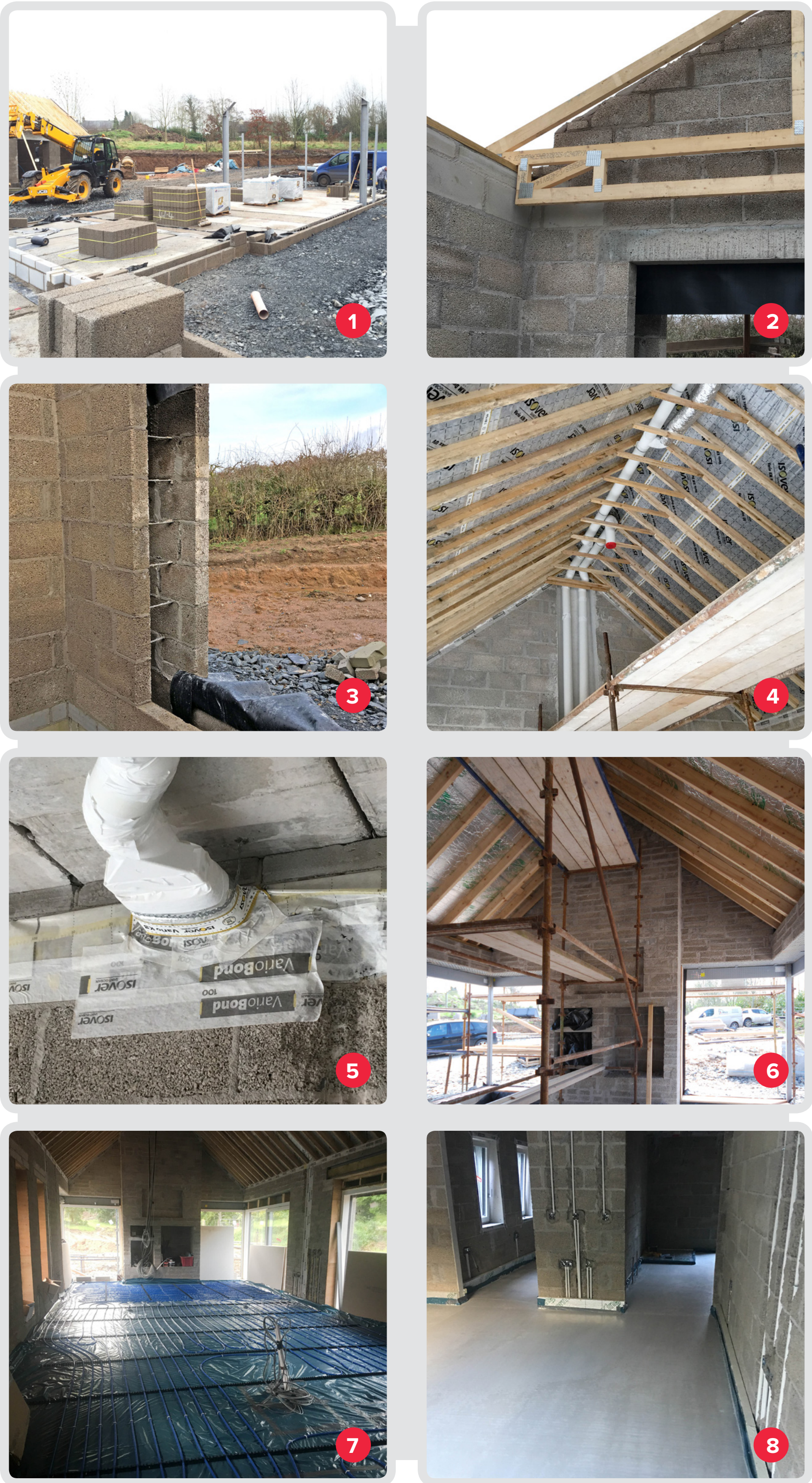
The calculations also show the house achieving an A1 building energy rating under the Republic's rating system. McAlister seems pleased with the result, seeing it as a vindication of the high quality of the design. "nZEB will be mandatory for all new homes from 1 January 2020 in the Republic of Ireland. In order to achieve it you need, basically, a passive house, plus some component of renewables."

While the original plan was to install an air source heat pump at Summerisland, that would have necessitated the installation of a new transformer on the local electricity network, a fairly costly upgrade. So, a condensing oil boiler was chosen instead, which distributes heat on the ground floor only via an underfloor heating loop.

There's also a 4kW solar photovoltaic array. McAlister is satisfied the oil will rarely need to be turned on. "The oil-fired burner was the smallest on the market," he says.

Photography: Oonagh McAteer / Rayoo Photography

CONSTRUCTION IN PROGRESS



1 The ground floor features pre-cast hollowcore concrete slabs and Quinn Lite blocks at the wall-floor junction; **2** The inner leaf is completed with two courses of Quinn Lite blocks coated in Weberend.Aid to provide adhesion for plaster; **3** the building's 250mm wide cavity walls; **4** Isover Vario vapour control and airtightness membrane to the roof, and ductwork for Dantherm heat recovery ventilation system at roof apex; **5** airtightness taping around ventilation ductwork; **6** 100mm Kingspan Therma TP10 PIR insulation board above roof rafters; **7** a condensing oil boiler distributes heat on the ground floor via an underfloor heating loop; **8** upstands of Kingspan insulation at the wall-floor-junction to minimise thermal bridging here.

SELECTED PROJECT DETAILS

Architect: Paul McAlister Architects
M&E engineer: George Dawson Ltd
Main contractor: Weir Bros Construction
Cavity wall insulation: Springvale
Thermal blocks: Quinn Building Products
Roof & floor insulation: Kingspan Insulation
Additional roof insulation: Isover
Windows & doors: Internorm, via Feneco
Roof windows: Velux
Oil boiler: Firebird, via main contractor
Kitchen: Greenhill Kitchens
MVHR: Beam Vacuum & Ventilation
PV panels: Solmatix Renewables
Passive house certifier: Mosart
BER: IHER Energy Services

> Summerisland surpasses the Republic of Ireland's planned nearly zero energy building (nZEB) standard, even though the standard will not apply in Northern Ireland.

IN DETAIL

Building type: Detached 302 sqm cavity wall house (TFA 274 sqm)

Location: Portadown, Co Armagh

Completion date: August 2017

Budget: Not disclosed

Passive house certification: Certified

Space heating demand (PHPP): 15.44 kWh/m²/yr

Heat load (PHPP): 12 W/m²

Primary energy demand (PHPP): 64 kWh/m²/yr

Heat loss form factor (PHPP): 3.87

Overheating (PHPP): 0% of year above 25C

Energy performance coefficient (EPC): 0.138

Carbon performance coefficient (CPC): 0.164

BER: A1 (21.79 kWh/m²/yr) (indicative)

EPC: A93

Measured energy consumption: Not measured

Airtightness: 0.4 m³/m²/hr at 50 Pa

Thermal bridging: First two courses of Quinn Lite blocks at wall-to-floor junction, low thermal conductivity cavity wall ties, thermally broken window frames. Individually calculated thermal bridges for each junction.

Energy bills (measured or estimated): Estimated annual bill of €94.26 for contribution of oil boiler to space heating and €25.66 for contribution of wood-burning stove to space heating, which equals €119.92 per year or approximately €10 per month. Estimated annual bill for hot water of €506.75 or €42.23 per month (based on 6.68 occupants). Figures are estimates by Passive House Plus based on projected delivered energy of the oil boiler and stove, occupancy figures from DEAP, and SEAI's published comparison of domestic fuel prices from January 2018.

Ground floor: 100mm screed followed beneath 250mm Kingspan TF70 insulation and pre-cast hollowcore concrete slabs. U-value: 0.086 W/m²K

Walls: 100mm blockwork externally, 250mm full fill platinum beads to cavity, 100mm blockwork internally. U-value: 0.126 W/m²K

Roof: SSQ Spanish slates externally on 50 x 35mm battens/counter battens, followed underneath by Tyvek breathable roofing underlay, timber rafters fully filled with 150mm Kingspan Aerofit EPS insulation between rafters, Isover Vario vapour control and airtightness membrane, 100mm Kingspan TP10 PIR above rafters, 50mm uninsulated service cavity, 12.5mm plasterboard ceiling. U-value: 0.112 W/m²K. Plus 450mm Isover Metac insulation at ceiling level to bedroom section. U-value: 0.091 W/m²K

Glazing: Internorm home pure KF410 triple glazed aluminium-PVC windows, with argon filling and an overall U-value of 0.71 W/m²K. Internorm HT400 timber-alu entrance door and KS430 lift-and-slide glazed door, both triple glazed.

Roof windows: Velux passive house roof window, GGU 008230, overall U-value of 0.51 W/m²K

Heating system: Firebird Heatpac C26 (20 – 26kW) oil-fired condensing boiler supplying underfloor heating to ground floor and a 300 litre buffer tank. Chesney's Milan 4 Passive 4.6kW wood burning stove.

Ventilation: Dantherm HCH8 heat recovery ventilation system. Passive House Institute certified to have heat recovery rate of 83%

Electricity: Solar photovoltaic array with average annual output of 4kW ■

EXTRA STOREYS

WHY WE SHOULD BUILD ON TOP OF OUR HOMES

Would you consider building an extra storey on top of your house? Would your neighbours, too? Making our urban environments denser by building upwards — on top of existing dwellings — could help to deliver more sustainable cities, closer-knit communities and a much saner housing market, say architects Tom Duffy and Karl Woods of Green Design Build

You don't have to be an expert in housing or construction to know that our property market is broken — you just have to be one of the many people who can't afford to buy or even rent the kind of safe, secure, affordable home that previous generations took for granted.

It's all down to the fact that not enough homes are being built, or in the right locations. The reasons for this are many and complex, but they can be tackled. One of the main factors is the existing low density of our towns and cities.

Both the UK and Irish governments are apparently considering radical moves to help tackle the housing crisis by making it easier for people to extend homes upwards, while simultaneously retrofitting their existing dwellings in the process.

Densification is about increasing the number of housing units, homes and bed spaces in an existing area, and using land more efficiently for development. The 'compact city' or 'city of short distances' is an urban design concept which promotes relatively high residential density with mixed land uses. It is based on an efficient public transport system and has an urban layout that encourages walking and cycling, low energy consumption and reduced pollution.

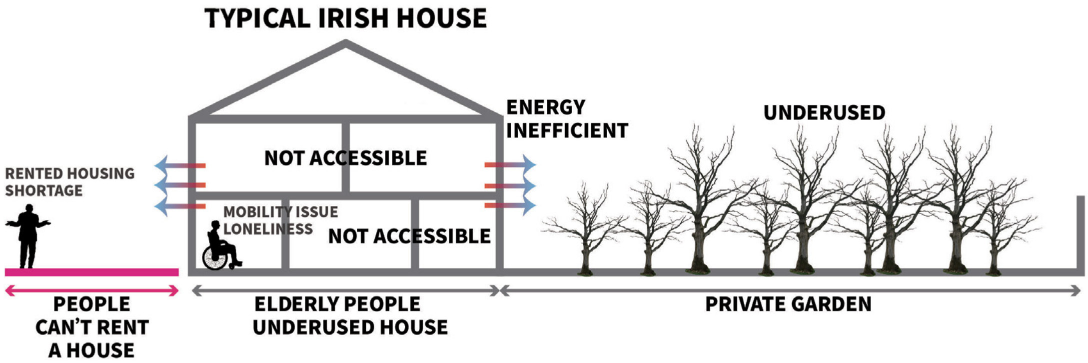
A higher concentration of residents provides greater opportunities for social interaction as well as a feeling of safety in numbers. It is less dependent on the car, and requires less infrastructure provision.

Creating a more compact city does not just mean increasing urban density across all parts of the city – it means good planning, resulting in a more compact urban environment. Not all development makes good use of land, especially in areas where demand is high and available land is limited.

When compared to other European cities like Barcelona or Paris, Dublin and London are relatively low-density, especially in their suburbs. When people picture high-density housing, they tend to think of unattractive tower blocks. But some of the most desirable places to live are in areas of higher density three or four-storey mansion blocks, mews houses and terraced streets.

Densification of our towns and cities can be achieved by building more housing units on our vacant urban and suburban brownfield sites, but it can also be done by building upwards on top of existing houses. The potential is there for everyone to add one or two extra storeys to their homes.

Many hundreds of thousands of houses built since 1950 have foundations capable of supporting an additional storey or two, and are in effect ready for redevelopment to unlock this potential.



(above) The increasingly common scenario in which privately-owned, energy inefficient housing is under-occupied but there is at the same time a shortage of rental accommodation on the market.

Densification would help the owners and tenants of today, who face rising rents, unfair fees and insecure tenures. It would help the homeowners of tomorrow by ensuring more of the right homes are built in the right places. And it would help to halt decades of declining affordability and to fix our broken housing market.

The bulk of existing houses built since the 1950s, although on the whole soundly constructed and sturdy, are generally cold, draughty, full of thermal bridges, and badly in need of a makeover. The opportunity to add an extra storey or two represents a potential bonus to the hard-pressed homeowner, giving them the opportunity to upgrade their house to passive or near passive standard. This is also an incentive for governments struggling to meet tough targets for carbon emissions from the built environment.

The addition of extra storeys could result in, on average, three more bedrooms per home, which would increase the value of each property. The increase in value would far exceed the cost of the build, with the typical cost in the region of €75,000 to €100,000. The quantity of building works involved in adding extra storeys for densification would also result in another swell in building works and additional funds for governments in the form of tax and VAT.

At the same time as creating more bed spaces and freeing up homes for other buyers, this kind of densification can also assist older people, the disabled and their carers by providing improved places to live and a better quality of life.

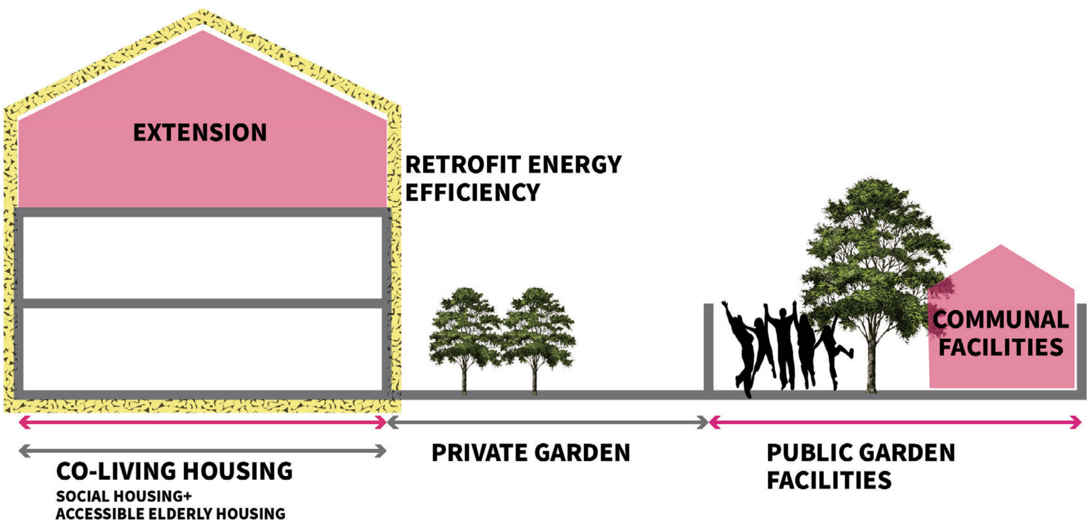
We can offer people a wider choice of accommodation for the future, help them to live independently for longer, and help reduce costs to the social care and health systems. There are currently many barriers to older people moving out of large family homes that they may have lived in for decades. There may be costs and fees, the moving process can be difficult, and people may have strong emotional attachments to their old family homes.

Thus, moving needs to be very attractive and suitable for the needs of older people over a twenty to thirty year period. There is also often a desire to be close to family, friends and community — which is much easier to achieve in more compact urban environments.

Downsizing by moving to a converted ground-floor unit within their existing home can offer older people a practical solution, while offering the chance to stay in the same community. The new units created above could be used to accommodate carers and family, or as a valuable new source of income through rental or sale.

Densification is also an opportunity to undo and solve planning mistakes made in the past, which created vast tracts of homogenous housing typologies. Adding extra storeys will result in a transformation of the urban and suburban landscape from a sea of three-bed semi-detached and terraced houses to a

> The potential is there for everyone to add one or two extra storeys to their homes.



(above) Retrofitting and extending existing properties to low energy and passive standards, and potentially developing them into new co-housing communities, could make more efficient use of existing housing stock.

Images: Green Design Build

"I wish this course had been available at the start of my career"
Daren, Architectural Technologist

"The knowledge gained from this course and how it will assist me in my work is well worth the time and very reasonable cost at the outset"
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diverse variety of modern low energy homes, from accessible one-bedroom ground floor units to larger family homes overhead.

It would enable us to transform our bland looking concrete plaster-dashed homes into colourful, vibrant, warm homes clad with up to 300mm of insulation — transforming Crumlin into Cartagena and Mayfield into Malaga.

The additional storeys could be constructed using either lightweight blockwork or ideally home-grown timber frame with wood-fibre external insulation for maximum environmental benefit. New roofs could be built to harvest rainwater and solar energy, helping to protect urban areas from flooding and giving people the opportunity to get off the electricity grid too.

Mortgage providers, banks and credit unions are now becoming increasingly interested in densification because it provides a new, low-risk product for them, with relatively small loans to homeowners and good loan-to-value equity ratios. These institutions just need to release funding at an attractive rate to encourage this kind of development.

Densification empowers homeowners to develop their own homes, to harvest the free equity development potential in the air-space overhead. This would permit significant expansion of the housing stock without over-reliance on large-scale housing providers or property developers.

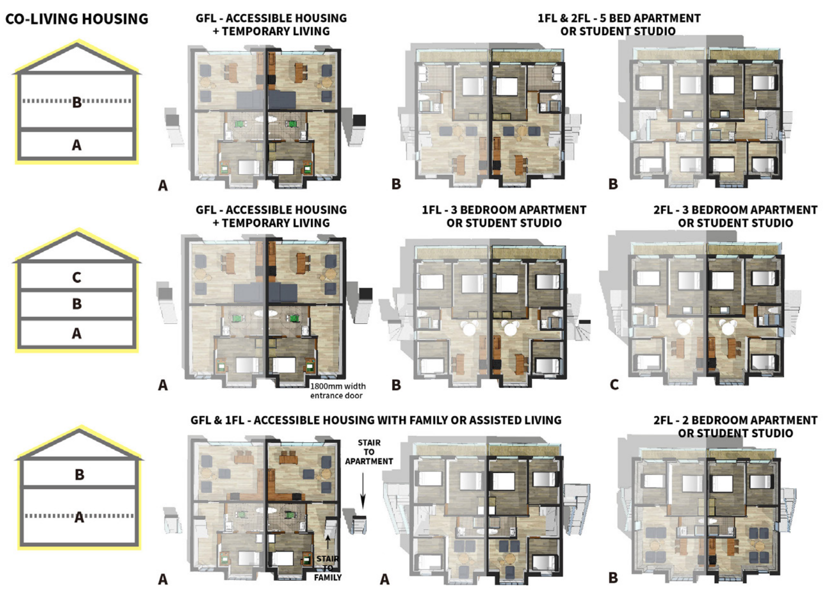
Our firm, Green Design Build, has recently spoken to high-ranking officials in the Irish government, and to Irish TDs and local authorities, about densification through the provision of extra storeys. The response has been positive.

Densification offers many positive benefits to society: an increase in bed-spaces in the right locations, taking pressure off the need for bed-spaces in other areas; the positive knock-on effects reducing excessively high rents and cooling the housing market; plus more comfortable homes, lower fuel bills and more diverse accommodation for the elderly and disabled in our existing communities.

> It would enable us to transform our bland looking concrete plaster-dashed homes into colourful, vibrant, warm homes — transforming Crumlin into Cartagena and Mayfield into Malaga.

Densification allows us the opportunity to transform, repair, reclaim, re-use, re-purpose and recycle the masses of poor-quality housing built since World War II. Some of this housing was built in a dubious — possibly corrupt — manner, without the proper schools and community facilities, which in turn has fostered social deprivation.

Densification is an opportunity for architecture to really give something positive back — to improve communities, create jobs and help us to deliver sustainable, warm, low-rise passive homes that are free from fuel poverty.



EMBODIED IMPACTS

HOW SHOULD WE MEASURE THE ENVIRONMENTAL FOOTPRINT OF BUILDING MATERIALS?

As new buildings become more and more energy efficient, attention is now turning to the wider environmental and climate impacts of the materials used to construct them — from the extraction of raw materials right through to how building components are disposed of at the end of their life. But how should we measure the 'embodied' impacts of construction — and how accurately can we even do it at all?

Words by Kate de Selincourt

The need to consider embodied impacts when making design choices is a familiar one in the world of sustainable building. We are told these might amount to 20 or 30% of the carbon footprint of an office building, say, or 25% of the lifetime energy demand of a passive house — clearly not something to be ignored.

Consideration of embodied impacts is now inching up the industry's agenda, though it is embodied carbon that gets most of the attention rather than embodied energy.

In some countries, such as the Netherlands, there are now statutory requirements to calculate the embodied impact of materials used on construction projects. Some UK local authorities also have policies on embodied impacts for construction.

The RIBA Awards, the UK's major architectural awards, have updated their project sustainability statement with several new categories, including product sourcing and embodied impact analysis for the first time. Meanwhile in Ireland, the Irish Green Building Council's new Home Performance Index includes analysis of embodied carbon as one of its key indicators.

Currently, the most familiar approach to assessing embodied impact is cradle-to-gate analysis. This is an attempt to measure the energy, carbon and other implications of a construction product — from sourcing the raw materials, through manufacture, to the factory gate. This is the approach recommended by the AECB CarbonLite Retrofit programme. (A free lesson on this subject is available on the AECB website via the news section).

AECB also suggests the use of Circular Ecology's ICE (Inventory of Carbon and Energy) database of materials, which is free, and relatively simple to use, focusing as it does on two indicators: energy and carbon. However, the information on ICE is not product specific, nor collected in conformity with an externally agreed standard.

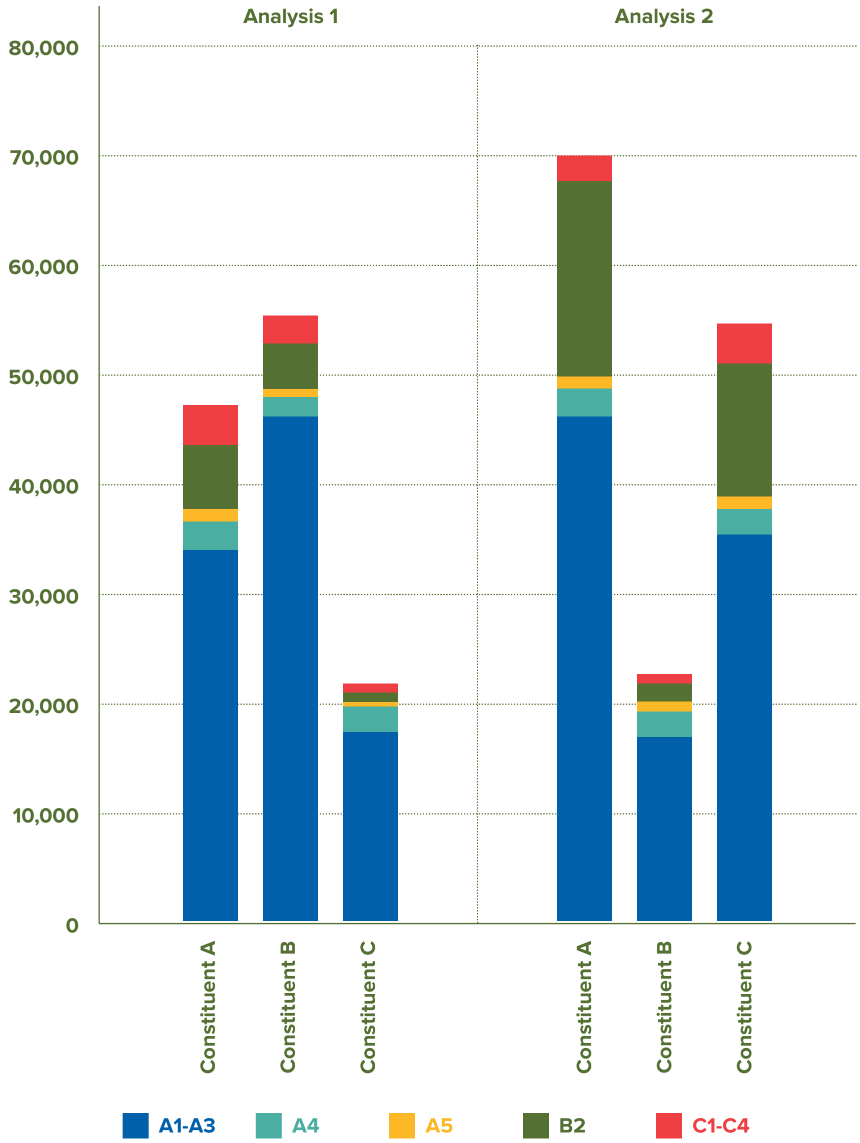
More detailed, and specific, product impact information is available for a subset of products via environmental product declarations (EPDs). These must conform to an international standard and are gradually increasing in number — over 5,000 at the last count — though it's fair to say the number of construction products that have EPDs is far outweighed by the number that don't.

A much more extensive approach than cradle-to-gate — life cycle analysis (LCA) — is now gaining attention. LCA considers emissions from raw materials processing through to manufacture, operation, maintenance/repair and disposal/recycling in one analysis (see graphic).

As engineering researcher at the University of Cambridge, Dr Alice Moncaster explains: "It used to be believed that if only you got the choice of structural material right, that was all that really mattered. This isn't the case. Several

> "The earliest emissions will do the most to change the climate in ours and our children's lifetimes.

Photo: Salah Ait Mokhtar



(left) The graphics show six different life cycle carbon analyses of the same construction project (a small residential development).

Three consultants each carried out two analyses of the same project – Analysis 1 assuming a shorter lifespan, Analysis 2 assuming a longer one. The total height of each bar represents the total life cycle impact calculated, expressed in $kgCO_2e$ / m^2. The subdivisions within the bars represent the stages of the lifecycle broken into 5 phases (see graphic on next page).

Furthering embodied carbon assessment in practice: Results of an industry-academia collaborative research project: Francesco Pomponi, Alice Moncaster and Catherine De Wolf, Energy and Buildings (accepted February 2018)

> Quibbling about the extra embodied impact of a third pane of glazing... risks downplaying the importance of occupant comfort and health, and of running costs.

detailed case studies have shown that the embodied carbon in replacing components — finishes, cladding, windows and doors, services components, 'low carbon' energy technologies — can be higher over the life of the building [than the initial construction]." Hence the interest in life cycle analysis from industry bodies such as RIBA and the Royal Institute of Chartered Engineers, which recently provided official guidance for its members on carrying out whole life carbon assessments.

As one LCA consultancy service puts it, LCA "allows you to...quantify your whole-building carbon footprint" and in the process "answer the simple question: how sustainable is my product?"

But is this really a simple question?

A life cycle assessment is a very different beast from a cradle-to gate assessment. The first difference, when considering carbon, is in the timing of the emissions. One of the arguments for paying attention to the embodied carbon of construction materials is that the emissions happen right at the start of the process, or as the AECB puts it, the "carbon burp".

Tonne for tonne, the earliest emissions will do the most to change the climate in ours and our children's lifetimes, because they will linger in the atmosphere the longest. And cradle-to-gate emissions are out in the atmosphere, doing their warming work, from day one.

Operational emissions begin now and build up over the years, joined over the decades by emissions caused by repairs and maintenance. Eventually, we get to emissions (or emissions savings) related to the end of a building's life.

Given the rising concern about how close we may be close to some climate tipping points — for example, the record high temperatures recorded in the Arctic last winter — it's legitimate to ask whether a tonne of carbon dioxide equivalent (CO_2e) emitted in 2080 should be given equal weight to one emitted today.

The other issue with the future is that it cannot be measured. Cradle-to-gate and operational carbon analyses do involve assumptions and guesses, but you can drill into more detail and carry out monitoring to verify your figures. But the future can only be guessed at. And scrutiny of life cycle assessments shows that even when a standardised approach is followed, these guesses may vary widely.

Research carried out by Dr Alice Moncaster and her colleagues compared three life cycle analyses of the same office building, and three of the same residential development.

The differences between the analyses were striking. As Dr Moncaster explained: "Not only were the total results (in $kgCO_2e/m^2$, kilograms of carbon dioxide equivalent per metre squared) different, but there were also huge differences in the assessments for each life cycle stage, even though these were all based on the same European TC350 standards.

Dr Moncaster's findings are echoed in a paper by Stephen Richardson of the World Green Building Council. His research indicates that "scenario level uncertainties" (i.e., speculation about what may or may not happen) are the biggest factor in variations between embodied carbon results. End of life assumptions (what they are, and whether to include them) turned out to be particularly critical to the final result.

Take glue-laminated timber (glulam) as an example. Depending on whether you count the carbon sequestered by the trees that produced

HOW DOES LCA WORK?

Product Stage			Construction Process Stage		Use Stage							End-of-Life Stage				Benefits and loads beyond system boundary		
Raw material supply	Transport	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D

(above) A full life cycle analysis wil consider the impacts of all the elements of a building, right through a full life cycle, from sourcing the raw materials to the ultimate fate of all components. The stages are standardised and named under European standards, as shown.

the timber, and whether you assume the glulam will be re-used, incinerated or landfilled (and what kind of landfill it will go to), Dr Richardson found embodied life cycle carbon totals across ten different analyses varied between -0.36 and +1.2 tonnes of carbon dioxide equivalent per metre cubed (tCO_2e/m^3). The only really consistent values were those of manufacture and transport (stages A2, A3 & A4), but at around 0.2 tonnes per metre cubed, their overall contribution was fairly small compared to the more uncertain stages mentioned above.

The demand for a final LCA score that can be benchmarked against other buildings tends to mean multiple elements of the analysis get rolled into one simplified figure, which is then quoted and compared.

But as the glulam example above shows, the impact of sequestered carbon is not always interpreted the same way. Indeed, there is disagreement about whether it should be subtracted from the building's embodied carbon at all, and where in the life cycle it should be counted.

If you count biomaterials as contributing 'negative carbon', you are essentially making assumptions about processes happening outside the direct control of the construction team — either because they are happening in the forest, or because they are determined by what happens to the timber elements of the building at the end of life (See 'Seeing the carbon for the trees').

Under the single score approach, the "negative carbon" from a high timber content might "offset" the emissions from, say, a less efficient building envelope. Yet this is the opposite of efficient resource use. (As an aside, this would not be the case if life cycle energy rather than carbon were being counted).

Can we offset embodied impacts?

This doesn't just apply when "negative emissions" are involved. Chasing after a single low carbon figure leads to the idea that it might be worth "trading off" a saving at one stage of a building's life to release a bigger saving elsewhere in the analysis — even if this means trading off something tangible in the here-and-now against an assumed benefit in the future.

Thus, it is not unusual to see discussions about whether the extra embodied energy is worth it for relatively small building elements such as windows, fans or insulation — technologies that may in themselves save energy or improve indoor air quality.

Sustainability consultant Julie Godefroy warns that it is not helpful to "trade" embodied against operational carbon. "I really don't think that we are at the point where our buildings are so operationally low-carbon that we should have these arguments," she told Passive House Plus. Pitting one against the other "[creates] a risk of diminishing attention on operational performance, when consultants still have to justify energy saving measures."

Quibbling about the extra embodied impact of a third pane of glazing not only downgrades the importance of operational energy, it also risks downplaying the importance of occupant comfort and health, and of running costs.

Thinking about tradeoffs also directs attention away from the biggest opportunities for both life cycle energy and emissions reductions – the basic design of the building. For example, in debating whether insulating to passive house level is worth the extra embodied energy, you might ignore the fact that passive buildings tend to have a much more efficient form — meaning they require less materials in the first place, and hence deliver a net saving of both embodied and operational energy.

Get in early

The number one item of advice from the experts Passive House Plus spoke to for this article was to start thinking about embodied impacts at design stage. "At the earliest stages, a design has the largest opportunity to change so the most savings can be made," says Craig Jones of Circular Ecology. It's generally much cheaper to make changes at this stage, too.

LCA expert Jane Anderson points out that larger buildings in particular are often over-engineered. On her blog, she reports that research at Cambridge University suggests buildings commonly use double the steel and concrete needed. The same applies to services, Julie Godefroy adds — meaning there are big wins from avoiding "excessive belt & braces approaches such as over-sizing plant and equipment."

And by designing a low energy building in the first place, you can reduce equipment size, or avoid it altogether. Designing simple, highly efficient buildings with little need for excessive bolt-on technologies is at the heart of good passive house design – and at the heart of low embodied impact design too.

The fact that much of a life cycle analysis is subjective does not mean it is worthless, though. "Even though we know that it is based on an imagined future which might not come about, personally I think the whole life should always be considered," Dr Alice Moncaster says. But that doesn't mean you should use your LCA to compare your building with others.

Even if you are not in a position to do a full life cycle analysis, you can still do your own investigation of your building's impacts — at least into the major elements of its construction, and think about how well the components will wear, and how easy they will be to dismantle and re-use.

But the message is, don't waste time chasing numbers, targets or benchmarks: if you are obliged to attach a number, interpret it with a hefty dollop of salt. "There are a vast range of methods out there for calculating embodied carbon, and they will all come up with a different answer," says Dr Moncaster. "We need life cycle analysis as a decision tool — not as an absolute number to report against."

> "By designing a low energy building in the first place, you can reduce equipment size, or avoid it altogether.

The UK's most wasteful industry

Cutting construction waste is one big-ticket way to reduce a building's embodied carbon or energy. "We're still the sector, by far, that is responsible for most waste production in the UK," says sustainability consultant Julie Godefroy. "Reducing construction waste is the big one, with the big long-term goal being the circular economy."

This means making it possible to re-use a building's components at the end of its life. As Alex Whitcroft of Bere Architects points out, buildings don't tend to fall to bits — more often, people decide they don't need them anymore. And if a redundant building can't be adapted to a new use, perhaps it could be taken apart and its components re-used?

This is not so fanciful. In fact, Simon Sturgis of the consultancy Sturgis Carbon Profiling told a meeting of the Alliance for Sustainable Building Products this spring that his firm had managed to persuade a client to dismantle and rebuild a 10-year-old building — retaining around 70% of the original materials in the process.

Seeing the carbon for the trees

While embodied carbon has rather trumped embodied energy as a metric in recent times, one danger of this approach is that carbon assessment lends itself to more 'creative accounting' methods— such as allowing carbon offsetting, or counting carbon sequestration (that is, carbon that is taken out of the atmosphere and locked up in wood as trees grow).

When 'negative' emissions are rounded into embodied carbon figures, they can overwhelm everything else (see graph). Accounting for carbon this way can even lead to a building being classified as 'carbon negative'. "The CLT sequesters the carbon within the material essentially making it 'carbon negative'…using CLT panels allowed a removal of approximately 539 tonnes of CO2 from the atmosphere," reads one architecture firm's description of a CLT project.

One danger with this approach is that it could encourage designers to put more timber into a building than is necessary, to artificially reduce the embodied carbon of the building. AECB CEO Andy Simmonds says: "I worry that encouraging people to use more timber, without being clear strategically as to whether it should be used in a high mass way, or whether use should be very efficient, could set up a culture [of] over-using the sustainably available resource."

And while designers typically regard timber as a low impact material, specifying it doesn't get you out of having to do your research. "I can't say that timber is always best without being specific to a certain function," says Craig Jones of Circular Ecology. Processing timber, for example — such as heating or gluing — can add unexpectedly to impacts, so it always pays to be as specific as possible.

The PH+ guide to INSULATING FOUNDATIONS

While understanding wall and roof insulation is relatively straightforward, insulation under the ground floor can be a bit of a mystery by comparison. Not only is it buried in the ground, but there are notoriously tricky spots like the wall-floor junction that need to be detailed and insulated properly. And the design of your foundation often depends on site conditions and the type of structure you're going to build, too. In this guide, we explain some different ways of insulating one of the most challenging parts of the building envelope.

Words by John Cradden

1 pouring a concrete slab over Xtratherm insulation with an upstand of insulation around the edges; **2** An Isoquick passive slab foundation at the landmark passive-certified UEA Enterprise Centre; **3** aerial view of a Kore insulated foundation system with two ring beams; **4** XPS insulation laid on the excavated ground floor of Ireland's first certified passive house retrofit project, designed by PH+ columnist Simon McGuinness; **5** 150mm Xtratherm insulation laid under the floor slab of Ireland's first passive house pharmacy, on a tight site in Tipperary; **6** Geocell, a foam glass gravel material that is both load-bearing and insulating.

The fabric-first based approaches required by tightening building regulations and best practice approaches like passive house are to a very large extent about ensuring high levels of unbroken insulation. That means the entire envelope – roof, walls, windows and ground floor. From hat, to jacket, to boots.

It goes without saying that one of the most important aspects to designing a passive house, or any high performance low energy building, is ensuring that whatever foundation system is used is well insulated and free of thermal bridges.

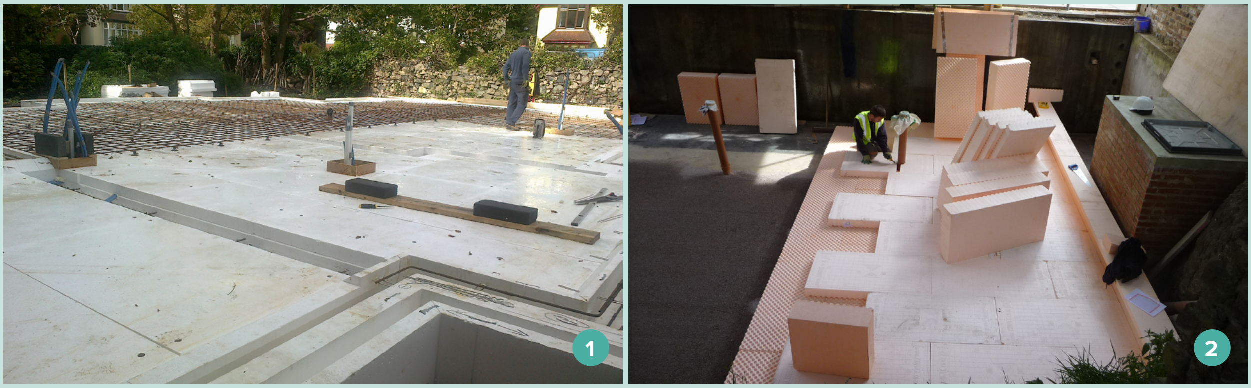
After all, the more you insulate the walls and floor of a house, the more heat that can escape from the thermal bridge at the wall-floor junction, increasing the risk of condensation and mould growth above the skirting. So insulating this junction becomes crucial.

Unless you are constructing a high-rise or multi-storey building, choosing the most appropriate insulated foundation type for a typical project looks simple on paper, with most of the head-scratching reserved for the finer details of the job on site.

It's unlikely that deep foundations will be needed unless the ground conditions are uneven or unusual in some respect. In most cases, the loads imposed by a typical low energy structure will be low relative to the bearing capacity of the surface soils, so the choice is generally between two types of shallow foundations systems.

Strip foundations are the more traditional and widely used in the UK and Ireland, where the walls are supported by a continuous 'strip' of foundation directly underneath the walls.

Raft foundations are basically reinforced



1 Kingspan's Aeroground EPS-insulated foundation system cut for double ring-beams to support the inner and outer leaf of a cavity wall; **2** the Isoquick insulated foundation system on the passive-certified Lansdowne Drive, London.

concrete slabs of uniform thickness that cover the entire footprint (though not always) of a building. They spread the load imposed by a number of columns or walls over the foundation area. As the name implies, this type of foundation essentially 'floats' on the ground like a raft floats on water.

Most passive house buildings tend to use insulated raft-type foundations where the concrete slab is poured into a 'bowl' or 'tub' of insulation that surrounds it entirely, insulating it from direct contact with the ground. The edges of this 'tub' of insulation are usually continuous with the wall insulation, and the method is generally more amenable to ensuring the foundations are thermal bridge-free.

So far, it might seem like insulated raft foundations are a bit of a no-brainer for low-energy buildings. However, it's rarely quite that straightforward.

The choice of foundation system, even on passive house projects, can often depend on external factors like ground conditions. Indeed, on sites containing shrinkable clays that can be subject to significant movement due to tree roots and other growths (a common enough issue), the traditional solution in these cases it to dig way down, using pile foundations.

That said, raft-type foundations are often chosen over strip ones where ground conditions are poor or settlement is likely, and can also have the edge in terms of speed and cost of construction because less excavation is usually required and less concrete used.

On the other hand, modern strip foundations and indeed other traditional types of foundation can also be brought up to standard in terms of radon barriers, proper insulation and thermal bridge-free design – indeed right up to passive house levels.

To take this point further, making a decision on a shallow foundation system based on the traditional understanding of how raft and strip foundations is to overlook the fact that some newer systems incorporate aspects of both raft and strip designs and seem to work well, while allowing for various build systems to be used — be it timber frame, ICF, cavity wall, externally insulated blockwork, etc.

For instance, there are a few variations on insulated raft foundations, with some systems having a 'ring beam' or two where the concrete is reinforced around the edges, while others don't. Indeed, some would argue that systems which incorporate ring beams are not really raft systems at all, particularly if the concrete slab isn't thick enough to be considered a raft.

So it may be that raft versus strip distinctions aren't really that relevant anymore when it comes to choosing how to insulate your home from what lies beneath.

Insulated foundation systems

Irish building materials giant Kingspan markets an insulated foundation system in Ireland called Aeroground, which is based on the Swedish Supergrund system (the company also offers a range of insulation solutions for conventional foundations). The load bearing walls and the floor slab of the building sit on top of an EPS layer, typically with trenches cut into the insulation near the perimeters for a ring beam of reinforced concrete to support the external walls, though the entire floor contributes to supporting the weight of the building. According to Kingspan Insulation operations manager Joe Condon, the design of the system varies depending on the wall loadings. For instance, the version designed primarily for a timber or steel frame construction has both an inner and an outer ring beam — one for the frame, and one for an external leaf of block or brick — that are both thermally isolated from the floor slab.

"While it looks like a raft, it is not an actual raft as the ring beam supporting the walls is separate from the floor slab," he said.

But the ground preparations are essentially the same as those for a raft foundation, in that the site is stripped and made totally level with a uniform layer of stone over the entire footprint of the house.

Another key player in insulated foundations is Kore, which markets a passive house-suitable insulated foundation system called Kore Insulated Foundation. Technical

Installation of the Kore insulated foundation system showing: **1** preparatory groundworks; **2** laying of the EPS tub with underfloor heating pipes and; **3** the floor slab poured.

sales manager Steven Magee is also keen to emphasise that the system in its standard form is not like a traditional raft foundation, but a system in itself.

"The issue is that because they look like a raft foundation, everyone calls them a raft foundation, but from a strictly engineering point of view they are not a raft foundation. They can be designed as a raft, but in their standard form they take elements of a traditional raft and elements of a strip footing foundation. It's an insulated foundation system."

Like the Kingspan version, EPS 300, with its high compressive strength, is used in conjunction with concrete and steel, while EPS 100 is used in three layers for the floor insulation. Depending on the design, there can be one or two ring beams involved, for instance to carry an inner or outer leaf.

There are a number of other systems based on a similar principles, such as Viking House's Passive Slab and Castleform's Raft Therm. But another household name in insulated foundation systems is Isoquick, which has no qualms about describing its product as genuinely raft-based.

Jonathon Barnett of Isoquick insists that, structurally, a raft is very different to a ring beam with a connected floor slab. "The ring beam design carries all of the load down through the narrow strip around the perimeter, with a thin layer of concrete in between the beams. This concentrates the load on a narrow strip of insulation, limiting the amount of load that can be carried."

He says that a ring beam design is essentially a strip footing with a reinforced beam, which by extension means the ground underneath the beam would have to be prepared to the same depth as a strip footing, although Kore and Kingspan say there is less need to excavate with their systems.

"Designing the slab as a flat raft means that the load from the walls is spread out, thereby enabling the foundations to be built where ground conditions are softer or more clayish," said Barnett. "It also simplifies the reinforcement design, removing or greatly reducing the need for time consuming wired cages of reinforcement."

A genuine raft design also works better thermally, too, he says, not least because the level of insulation under the edge of the slab remains consistent. Ring beam designs require the concrete slab to be thickened at the edges, meaning that the insulation has to be reduced compared to the middle of the building. "All of our details can be designed to achieve a passive standard at the ring beam," said Magee.

Arguments about thermal performance aside, perhaps the choice among architects depends more on the versatility of all these systems in terms of accommodating the various different types of structure, but for others the appeal of a flat raft system may well be its inherent simplicity in terms of ensuring optimal thermal performance.

Another factor, of course, is cost. Insulated foundation systems may cost more materially, but one argument is that they require far less soil or ground excavation than traditional foundations, including the need to dig up trenches, which in turn speeds up construction and cuts down the risk of health and safety issues.

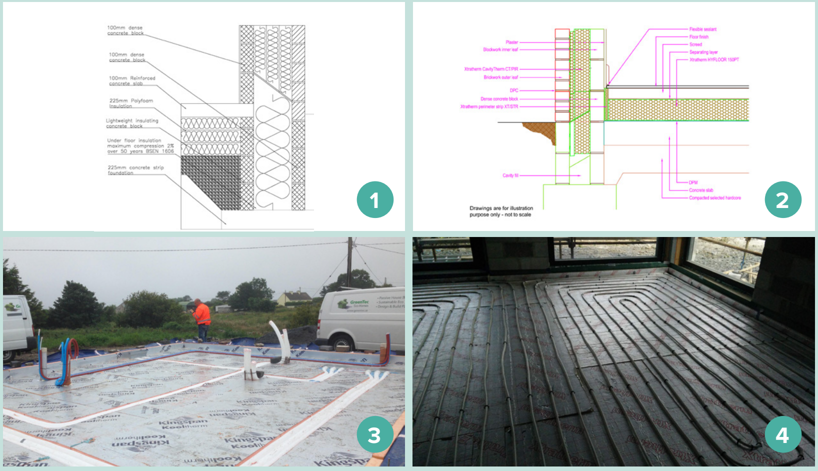
"Removing the muck is simple and straight forward without the trenches," said Barnett. "Likewise the sub base and levelling stone take only a day or two to prepare. Once the stone is in place your site is out of the mud making life easier for everyone working on the job. From an empty site to a finished floor is usually less than two weeks. We win contracts simply on the muck away savings alone."

Structural engineer Hilliard Tanner is also of the view that overall, the costs even out between insulated and non-insulated systems. "We have done a number of insulated foundations that work out cheaper overall than traditional strip foundations," he said.

Insulated foundation systems are certainly attracting more attention from bigger contractors, "because they work really well with modular housing as well and builders like the idea of reducing the skilled labour required on site", says Steven Magee of Kore.

There is also the reduction in concrete use with insulated foundations. "From a cost point of view, you use a lot more polystyrene than you would in a traditional foundation, but that is offset by using approximately 50pc less concrete," Magee adds.

Furthermore, there is an element of pre-fabrication with such systems in that you are more likely to see the exact specifications of the foundation upfront, including the amount of insulation and concrete used. This can minimise the likelihood of mistakes and material wastage on site. "From a QS point of view, it allows them to work out exact quantities of materials that will be needed up front – as opposed to traditional strip foundations where you dig a trench and approximating the amount of concrete required to fill it."



1 Foundation detail at Denby Dale, the UK's first certified cavity wall passive house, with a lightweight insulating concrete block at the wall-to-floor junction; **2** Xtratherm detail showing upstand of insulation around the edge of the floor slab to minimise thermal bridging with the inner leaf of the cavity wall; **3** 200mm Kingspan insulated strip foundation with 70mm upstand to edges under a passive house in Inverin, Co Galway; **4** this passive house in Co Meath has a strip foundation with 200mm Xtratherm under the concrete slab, which also encases the underfloor heating pipes, and Quinn Lite thermal block at the wall-to-floor junction.

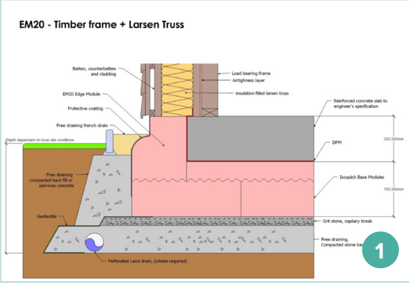
As mentioned earlier, ground conditions remain the biggest factor, meaning that strip or pile foundations may be a better choice when the soil is softer or subject to potential disturbance from nearby tree roots, or if the wall loadings of a given structure are likely to be too heavy in parts, or if the site in question contains aquifers.

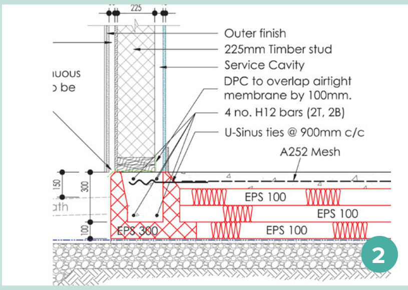
Magee says that Kore's system can be used in almost any ground conditions. "If ground conditions are poor, the system can be designed more like a traditional raft, whereby ground beams and ribs within the slab are incorporated to make the entire system act monolithically. In the case of very poor ground conditions, e.g. on filled ground, the raft can bear onto standard piles, but whilst also maintaining a complete thermal break between the piles (ground) and the raft". In any case the system needs to be designed by a suitably qualified engineer based on the ground conditions and superstructure.

Strip foundations

While a common refrain among raft foundation advocates is that strip foundations can lead to thermal compromise when compared to insulated foundation systems, Passive House Plus has featured plenty of projects over the years, of various construction types, that have achieved the passive house standard with a traditional strip foundation.

The key is good detailing. This can mean wall insulation that continues down below ground level, reaching down below the floor insulation, and ensuring a sufficient overlap of thermal insulation between the wall insulation and underfloor insulation. Given that ground temperatures below certain depths remain relatively warm compared to external conditions, the absence of insulation beneath the blockwork separating the wall insulation and floor insulation may be a non-issue – if





1 Detail showing the Isoquick insulated foundation system under a timber frame wall; **2** drawing illustrating the floor-to-wall detail for Kingspan's Aeroground insulated foundation system; **3** 200mm of PIR insulation to provide insulation under the ground floor of a passive house scheme in Essex, which had an innovative approach to a traditional strip footing.

the insulation layer is brought down below the floor insulation level. For instance, leading Irish insulation manufacturer Xtratherm recommend the wall insulation layer being brought down to a depth of 225mm below the floor insulation layer.

If there is insulation on the room side of the wall build-up — for example on the inside of a timber frame —thermal bridging at this junction can be minimalised by, for example, installing an upstand of insulation around the edges of the floor slab that join with the room-side insulation as per the ACDs (Acceptable Construction Details).

Equally, a common detail for masonry projects is to have a low thermal conductivity block at the base of the inner leaf of masonry, where the wall meets the underfloor insulation, to minimise heat loss through this junction.

Xtratherm told Passive House Plus it had conducted an extensive thermal analysis of a wide range of products on the Irish market designed to effectively insulate floors and floor/wall junctions.

"Curiously, many of the system suppliers do not quote a resultant Psi value for this junction," said Mark Magennis, senior technical adviser at Xtratherm. Magennis said that the resultant Psi values from well-detailed insulated strip footings are generally comparable to insulated foundation systems.

"Yes while there can be a reduction in the Psi value with some insulated foundation systems, traditional strip foundations detailing with the use of medium density blocks and careful detailing of conventional insulation also reduces the Psi value," he said.

The company's own detail is based on the Irish acceptable construction details (ACDs) and allows for typical compressive loadings for dwellings, and radon detailing in accordance with Irish EPA guidelines.

"It can also dispense with the requirement for bespoke engineering calculations as required with foundation systems," Magennis said.

The detail employs the company's CavityTherm Foundation Riser boards in the cavity, extending below the damp proof course (DPC), ensuring at least 225mm overlap from the top of the floor insulation. It features a radon barrier dressed across the cavity, dissecting or weaving under the insulation and then extending under the floor insulation.

Magennis said that for anyone looking to decide on a foundation system, the key thing is that the performance of products and system is clearly defined, and performance claims are published and certified by a suitably qualified person – such as an NSAI-registered thermal bridging modelling assessor – in a way that is easy to understand. He also emphasised the need for "better and easier detailing on site".

Another alternative to insulated raft or strip foundations is Geocell, a foam glass gravel material that works as a lightweight exterior insulation and sits below the floor slab. It is load-bearing, with a comparable compressive strength to a hard-core, and free-draining. The system is passive house certified and offers similar thermal performance to mainstream insulation systems, with a lambda value of 0.08 W/m²K. It is made entirely from recycled glass, and distributed in Ireland by Linham Construction.

Retrofit

Of course it's probably no surprise to learn that, short of lifting up the entire building, it's practically impossible to retrofit insulated foundation systems.

But there are some measures that can be reasonably cost-effective to implement, such as digging out the ground floor and adding insulation. "What you'd be doing there is to dig out the floor down to a level that would be compact enough to create a level base, put in your insulation and put down a floor slab and put a slip of insulation around the perimeter to create a cold bridge divider between the floor slab and the lower part of the inside wall," said Joe Condon of Kingspan.

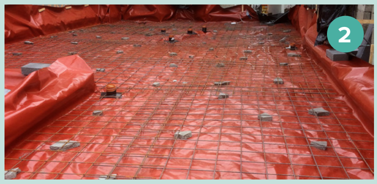
The biggest issue would be waterproofing and keeping the load-bearing structures in place while you rip up the floor.

Another step might be to bring external insulation down below ground floor level to address thermal bridging. Sometimes, just bringing external insulation deep enough down underground will be sufficient as, once you get below certain depths, ground temperatures pick up anyway.

Radon barriers

In areas that have been listed as having high radon levels, Irish and UK building regulations generally stipulate that new buildings should be fitted with a strong radon barrier and sump, while areas less affected may still need some basic protective measures.

According to Hilliard Tanner, with insulated foundation systems as he details them, the radon sump goes into the top of the fill as normal, and then barriers are placed under the insulation, and leaving it out past the sides of the insulation. Alternatively, you could run the barrier on top of the first or second (of the three) layers of floor insulation, then in contact with the ring beam.



Foundation at an A1-rated social housing project by Linham Construction in Dublin, showing **1** Geocell foam glass gravel and aggregate under the concrete slab; **2** followed above by a radon barrier and; **3** 225mm reinforced concrete with a power float finish.

Next issue...

The PH+ guide to:

Airtightness

Why is airtightness increasingly viewed as such an integral part of low energy building? What are the best solutions available to ensure airtightness with different build methods - and how ambitious can we really be about airtightness in retrofit projects? Our next guide will look at all of these issues, among many more.

Marketplace News

Understanding SFP crucial to MVHR choice — CVC Direct

One of the key elements that influences choice of mechanical ventilation with heat recovery (MVHR) units is specific fan power (SFP), says leading MVHR supplier CVC Direct. The basic principle of the passive house standard is to reduce energy demand, and SFP is a key indicator for measuring the energy efficiency of the MVHR unit. The lower the SFP, the more efficient the system.

SFP can be defined as a measure of the efficiency with which a given volume of air can be moved. In an MVHR unit the SFP relates to the total power input to the fans, controls, preheater etc, divided by the maximum airflow. SFP for MVHR units is usually expressed as watts of power per litre of air per second (W/l/s) or watts of power per meter cubed of air per hour (W/m^3/hr).

MVHR systems are often used in passive house construction and the minimum performance requirement for a passive-certified MVHR unit is an SFP of 0.45W/m^3/hr. It is important to note that the Passive House Institute (PHI) and the Standard Assessment Procedure (SAP) test methods are different, so the results for SFP aren't directly comparable.

The Brink Flair 325, supplied by CVC Direct, achieves an SFP of 0.19W/m^3/hr (PHI), which is 30% lower than the previous model and considerably better than similar products on the market, the company said. This is the result of improved aerodynamic design and unique fans which are equipped with an integrated control system to ensure constant flow of air.

The SFP is not fixed for any MVHR unit but fluctuates based on the air flow rate and system pressure. The Brink Flair 325 has constant volume fans and will continually adjust to provide the commissioned air flow. Added system pressure from excess bends in the ductwork, or blocked filters, will result in the fans working hard and increase the SFP. For more on the system see **www.cvcdirect.org**. ■

(below) The Brink Flair 325, supplied by CVC Direct, achieves an SFP of 0.19W/m^3/hr.

Ecological host UK-wide airtightness seminars

(above) The Pro Clima Intello Plus intelligent airtight membrane, which recently gained BBA certification.

To celebrate BBA approval of its Pro Clima Intello Plus intelligent airtight membrane, Ecological Building Systems and Pro Clima have announced a seminar tour that will bring airtightness insights to five locations around the UK.

Kicking off at the National Self Build and Renovation Centre in Swindon on 16 October, the airtightness tour then visits London, Belfast and Glasgow before culminating at The Studio in Birmingham on 22 November.

Each event will include a packed full-day programme of technical presentations and discussion topics from Pro Clima, the Ecological Building Systems team and the BBA, along with practical installation demonstrations, a guest keynote speaker and a round table discussion. The seminars can be counted as six structured CPD points and attendance includes lunch and refreshments, with opportunities for networking and informal discussion.

Ecological Building Systems has launched a dedicated website for the seminar tour, **www.intellosealofapproval.com**, where delegates can register their interest and secure their place, with early bird discounts available on the standard delegate fee of £80 including VAT.

Niall Crosson, group technical manager at Ecological Building Systems, said: "The BBA's seal of approval for Pro Clima Intello Plus gives specifiers complete peace of mind that the membrane will deliver on its promise of humidity variable airtightness, for more energy efficient environments with enhanced building comfort with reduced risk of structural damage from trapped moisture, thanks to Intello's unique hydro-safe properties."

This is particularly crucial given the extremely high levels of humidity often experienced on building sites throughout the UK. The opening presentation at each seminar, from the BBA technical excellence team's senior scientist, Jon Denyer, will outline why respected standards and the testing they involve are so critical in the built environment sector.

Niall Crosson continued: "The purpose of the seminars is to demonstrate the increased thermal performance and year-round building comfort that can be achieved by improving airtightness across both residential and commercial buildings, in new builds and retrofits."

Crosson will also be delivering presentations at each seminar, alongside Pro Clima's head of applications technology Michael Foerster. Each event will also include a discussion of a local passive house or low energy project. ■

(above) Aileen and Patrick Beausang of Passive Sills with their commendation under the 'best product of the future' category at the SEAI Energy Show.

Passive Sills gets Agrément cert

Passive Sills, the Cork-based manufacturer of insulated window sills, has now received an NSAI Agrément certificate for its passive sills system. The company also told Passive House Plus that it was expecting to get its British Board of Agrément certificate imminently, too.

The passive sills system is certified by the Passive House Institute, and is constructed from a high density EPS core that is coated with a polymer resin.

Traditional concrete and stone sills pose a major challenge for low energy and passive buildings, because they act as a major uninsulated thermal bridge through which heat can escape. Passive Sills has essentially turned this problem on its head by manufacturing its sills out of EPS, an insulating material.

Passive Sills was also commended in the 'best product of the future' category at this year's SEAI Energy Show, which was held in the RDS, Dublin in April. The company is currently working on a number of major projects, including a new development of 160 homes in Ashford, Co Wicklow by leading low energy housing builder Ecofix, and even in developing thermal details for social housing in Belgium.

"Another thing we hear a lot is that builders love the product because it completely eliminates all of the manual handling issues associated with traditional heavy concrete and stone sills," Patrick Beausang of Passive Sills told Passive House Plus. "A standard concrete or stone sill will weigh about 60kg per linear metre, whereas our sill weighs about one-tenth that amount."

Beausang added that the product was also proving surprisingly popular with timber frame builders, because its light weight makes installation significantly easier than a heavier concrete or stone sill. ■

Landmark West Yorkshire mill rebuilt with Nudura ICF

(above) The Nudura system was used with reclaimed stone to seamlessly rebuild & renovate Corn Mill Farm in West Yorkshire.

Corn Mill Farm, a landmark old mill building in West Yorkshire, has undergone an extensive rebuild and renovation using Nudura insulated concrete formwork (ICF) panels to bring it up to modern standards of comfort and energy efficiency, while retaining its original appearance.

Following the renovation, Corn Mill Farm has become one of the elite luxury properties in West Yorkshire, enjoying outstanding views of the surrounding countryside. The refurbishment of the 300-year-old water-powered mill also retained the original water wheel and mill pond.

Prior to the extensive renovation, the mill pond on a higher level was seeping and had destabilised the buildings' structure. The mill had been seriously damaged by the constant flow of water through the structure, and the top two floors had to be carefully demolished and rebuilt.

The 1,068 square metre (floor area) project required extensive demolition and rebuilding using reclaimed stone from the site. Total construction time was 78 weeks by ICF contractor and Nudura distributor Landmarks UK, with some 80 days spent on Nudura ICF installation time (covering 803 square metres). Nudura ICF was specified for the rebuild because it could allow for continuous construction throughout the harsh winter and meet numerous waterproofing challenges.

A concrete ring beam was cast onto the partially demolished external walls, and Nudura 96-6 ICF panels used to rebuild the internal skin.

Reclaimed stone from the barn was used to clad the Nudura, so that it is impossible to distinguish between the old and new parts of the build.

The building was rebuilt in stages to meet imposing standards required by BS8102 2009 on waterproofing. The vertical joints in the Nudura wall were protected against damp penetration with vertical water bars, and the concrete stitched together with steel pins.

Self-healing waterproof TT Admix was mixed in by the batching plant, and all concrete pokered to eliminate air bubbles.

The wine cellar sits on an even lower level than the mill. The water pressure here was high and the existing walls in perilous condition. The floor above the cellar was removed and the cellar pumped dry. A new water-proof slab was cast, Nudura 96-8 panels were used to line the existing cellar structure and filled with waterproof concrete. The cellar is now dry, and the wine kept at a constant temperature. The renovation, by architects Studio Map Ltd, recently won the 2018 specialty project best in class award at the international ICF Builder Awards. The project was also runner up at the West Yorkshire LABC Building Excellence Awards in the 'restoration and conversion — small projects' category.

Jean-Marc Bouvier, Nudura's director of sales and business development, told Passive House Plus that the company's ICF system can achieve U-values down to 0.21, 0.18, 0.16, 0.14, 0.11 – even as low as 0.05 — using its Nudura Plus and insert products.

He also said that independent testing by RDH Building Engineering Ltd has shown that when a Nudura wall alone is assessed, it can achieve airtightness as low as 0.01 $m^3/hr/m^2$. ■

Hi-therm+ wins Housebuilder building fabric award

Keystone Lintels has won the 'best building fabric product' award at the 2018 Housebuilder Product Awards for the company's Hi-therm+ lintel.

Keystone said that it has invested heavily in R&D to re-engineer its Hi-therm lintel utilising its industry leading 'top hat' design. The innovative design of the Hi-therm+ lintel, while still utilising a rigid polymer thermal insulator as an effective thermal break, now incorporates a steel inner and external leaf.

The company said that the product is as thermally efficient as the original but is now similar to a standard steel lintel for simplified installation. Hi-therm+ offers specifiers a low-cost solution to reduced carbon emissions.

Keystone Lintels managing director Derrick McFarland commented: "Keystone recognises the challenges facing house builders in relation to the increasingly demanding regulatory controls on thermal performance and sustainability.

"We recognise that a fabric-first solution is preferable to builders, particularly something that is easily installed, maintenance-free and can allow them to design with 100mm cavities to ensure maximum floor space in developments.

"We are therefore proud to have been recognised for our commitment to the fabric-first approach. Our original Hi-therm lintel won this award in 2013 and 2014, so for our innovative new design to be recognised again is fantastic."

As winners of a Housebuilder product award, Hi-therm+ lintels automatically become a finalist in the overall 'product of the year' category at the Housebuilder Awards 2018, which will be held in November. For more information visit **Hi-thermlintels.com**. ■

(right) David Grace (second from right), sales director for Keystone Lintels, picks up the award for best building fabric product at the 2018 Housebuilder Product Awards.

MBC blitzes airtight test on latest passive house project

Leading low energy timber frame manufacturer MBC Timber Frame has completed work on another project aiming for the passive house standard.

Situated in rural Norfolk, this new house features MBC's cellulose-insulated passive wall and passive roof systems, which deliver U-values of 0.12 and 0.10 respectively. The dwelling has achieved an airtightness test result of 0.43 air changes per hour, and is set to be complete in September of this year.

"When we found a site with an old barn with planning permission we decided to self build," said homeowner Samita Mukhopadhyay, who added that energy efficiency was her number one priority for the build. "MBC seemed to listen to me and take time to explain everything to me that I needed to know," she added.

Mukhopadhyay told Passive House Plus that, when finished, the house will feature mechanical ventilation with heat recovery (MVHR), and a solar PV array to electrically heat water for a small amount of underfloor heating pipework.

Mukhopadhyay plans to keep a small pond on site for wildlife and will be providing new 12 bat-boxes too. When asked what she wanted from her new home, she said: "I wanted a simple functional house, which would hopefully be beautiful too." ■

(right) MBC's latest passive house in Norfolk features Coillte's ProPassiv airtight OSB along with Partel membranes.

Ancon wins Queen's Award for innovation

(above) Ancon divisional manager Hervé Poveda and TeploTie inventor Ben Williams of Magmatech at a royal reception at Buckingham Palace for the Queen's Awards, with Prince Charles in the foreground.

Ancon was honoured at a royal reception on 28 June to celebrate its success in the 2018 Queen's Awards for Enterprise, the company's third such award.

The company picked up the award in the innovation category this year for its advanced composite, low thermal conductivity, Teplo wall tie range.

Launched by Ancon in 2010, Teplo wall ties are manufactured from continuous basalt fibres set in a resin matrix, a fibre-reinforced polymer that is 70 times more thermally efficient than steel. When used to join the two leaves of a cavity wall, this material virtually eliminates cold bridging across the insulated cavity.

Teplo has been used in numerous ground-breaking projects, including the UK's first masonry cavity wall passive house (Denby Dale) and the largest building in the UK built to the passive house standard to date, the University of Leicester's Centre for Medicine.

Head of marketing and innovation at Ancon, Annabelle Wilson, said: "Ancon launches a number of new and improved structural fixings every year and invites ideas into our innovation process from both inside and outside the company.

"We saw potential in this new material immediately, and over the last eight years have committed our business resources to improving and extending the Teplo wall tie range as part of the Ancon product portfolio, bringing the benefits of advanced composites to mainstream UK construction."

Speaking after attending the royal reception, Hervé Poveda, divisional manager with Ancon, said: "It was a wonderful personal experience to meet the royal family at Buckingham Palace and a great honour to be asked to represent Ancon at this event. A Queen's Award not only recognises expertise in developing new products or achieving commercial success, but also excellence in every area of business."

The Queen's Awards for Enterprise are presented annually for outstanding achievements in the categories of innovation, international trade and sustainable development. Ancon previously won a Queen's Award for international trade in 2015 and one for innovation in 2011, for its patented lockable dowel.

The 2018 Award will be officially presented to Ancon later in the year when the Lord Lieutenant of South Yorkshire, the Queen's local representative, visits the company's recently-extended production facility in Sheffield. ■

Stunning Bath home features Urban Front oak doors

A stylish new low energy home within a World Heritage Site on the outskirts of Bath is one of the latest projects to feature an e98 passiv front door from UK manufacturer Urban Front.

Designed by Casa Architects, the Carrisbrooke residence was designed in PHPP according to passive house principles, though not certified, and achieved an airtightness of 1 air change per hour. It sits within the Bath World Heritage Site, famous for its architecture.

The e98 passiv door was specified for the dwelling in Urban Front's Neo pattern, featuring widening horizontal grooves in the European oak finish.

Urban Front holds a passive house certificate for the e98 passiv door, though it is not certified for the 1095mm x 2690mm dimensions specified at Carrisbrooke. The door boasts a U-value of 0.8 and class three airtightness.

The brief from the client at Carrisbrooke demanded a highly sustainable home, and the dwelling was constructed from a closed-panel timber frame system that came pre-insulated with wood fibre.

For more on e98 passiv see **www.urbanfront.com**. ■

(above) The e98 passiv door at the Carrisbrooke residence came with Urban Front's Neo pattern, featuring widening horizontal grooves in the European oak finish, and boasts a U-value of 0.8.

PH+ **HELP DESK**

UK EXPORTERS:
mind the regulation gaps

With Irish building regulations advancing ahead of the UK in terms of both designer liability and technical issues like calculating surface temperatures to avoid mould risk, Simon McGuinness warns that UK suppliers may have work to do before entering the growing Irish market.

With the news full of Brexit, I thought I'd give UK manufacturers and suppliers of building materials a little wake-up call regarding the divergence between UK and European building regulations when it comes to the issue of surface temperature calculation and the avoidance of mould.

This issue has largely gone under the radar due to ignorance of the foreign regulations on the UK side of the Brexit border, aided and abetted by a certain amount of denial on the other. Perhaps unsurprisingly, Irish specifiers of UK building materials find themselves on the front line in this regulatory divergence. The gable wall junction below has been modelled in accordance with both Irish and UK regulations for critical surface temperature, fRsi. It passes one and fails the other: the Irish regulation being the more onerous. This matters if you are selling products into the Irish market because if you have modelled junctions containing your products it is likely to be based on BR497, the UK national "Convention for Calculating Linear Thermal Transmittance and Temperature Factors".

BR497 was revised as recently as June 2016 and appears to have failed to align with the harmonised European norm hEN ISO 13788 for surface temperature calculation. Whether this was a just the anti-EU Zeitgeist of the time, or a determined effort to remain unmoved in the face of evidence from Fraunhofer and others showing mould in European buildings designed in accordance with the lower standard, is not clear. The fact is that the ISO standard was tightened in 2012, in the light of empirical evidence, to make it less likely that mould would appear inside dwellings.

The difference between BR497 and hEN ISO 13788 amount to three numbers representing the surface resistance to be applied in fRsi modelling. In the case of BR497 those figures are 0.13 m^2K/W for walls (horizontal heat flow), 0.10 m^2K/W for ceilings (upward heat flow) and 0.17 m^2K/W for floors (downward heat flow). In the case of the harmonised European standard all three are set to 0.25 m^2K/W.

The actual wording used in 4.1.1 on page 6 of hEN ISO 13788 is:

"For condensation or mould growth on opaque surfaces, an internal surface thermal resistance of 0,25 m2·K/W shall be taken to represent the effect of corners, furniture, curtains or suspended ceilings, if there are no national standards."

The reference to corners, furniture, curtains or suspended ceilings is recognition that where these elements shield walls, floors or roofs from full exposure to the convection of internal heated air, there is an increased risk of surface condensation. We have all seen instances where you pull out a wardrobe or bed only to see its shape recorded in mould on the wall behind. The increase in surface resistance due to lower convection at those locations is exactly what leads to this phenomenon.

As a building designer is unable to determine where furniture will be placed within a room, or how much of a wall may be covered by curtains (or pictures or wall hangings of one sort or another), the only way to determine compliance for mould avoidance is, therefore, to apply the 0.25 m^2K/W generally.

Even this may not be sufficient to ensure the avoidance of mould, but it is sufficient defence in law to prove that the designer is not liable. The designer has done their job: their design has complied with the building regulations.

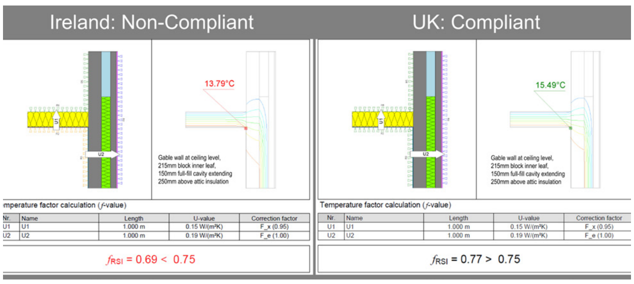
This change from 0.13 to 0.25 m^2K/W for a wall may seem like a small change, but it has a very large impact on a model of a thermal bridge. It can mean the difference between compliance and non-compliance, between a designer being held liable in the event of mould occurring or not being liable.

Irish design certifiers are held to a far higher compliance threshold than their UK counterparts and work under a much stricter building control regime. UK suppliers into the Irish market will need to be absolutely sure that their products comply with the Irish building regulations if they expect Irish designers to specify them. Irish specifiers will need to ensure that the correct modelling convention has been applied.

It is important to understand that it is not Ireland that is out of step here. Ireland just applies the international standard, rather than the UK national standard, in its building regulations. This is the standard that applies widely across Europe, and beyond, so exporters into those markets need to understand the territorial limits of the UK's national standard, BR497.

To add further to the complexity, the convention for modelling heat loss through junctions is the same in the UK and Ireland, as it is across Europe. In that case, the procedure used in BR479 aligns with international standards. The elevated surface resistance factor of 0.25 m^2K/W applies only to surface temperature calculation, which is the procedure used to predict mould inside buildings.

A casual reader of the Irish regulations could be forgiven for reading what they would like to see, rather than what is actually there. An Irish design certifier defending a damages claim for mould doesn't have the luxury of being casual with the Irish building regulations. Nor should UK exporters. ■



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